# Evaluation of the Life History of Native Salmonids in the Malheur River Basin

## Cooperative Bull Trout/Redband Trout Research Project

**Annual Report**
**2001 - 2002**

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Burns Paiute Tribe

# Evaluation of the Life History of Native Salmonids in the Malheur River Basin

**April 2001-March 2002 Annual Report**
**(March 2003 Version 2.0)**

Prepared for:

U.S. Department Of Energy
Bonneville Power Administration
Division of Fish & Wildlife

# Evaluation of the Life History of Native Salmonids in the Malheur River Basin

## 2001-2002 Annual Report for BPA project #19970190)


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# General Introduction

The Malheur River is a 306 km tributary to the Snake River, which drains an area of 12,950 sq. km. The Malheur River originates in the Blue Mountains (Buchanan et al. 1997) and flows into the Snake River near Ontario, Oregon. The climate of the Malheur Basin is characterized by hot dry summers, occasionally exceeding 38$^{o}$C and cold winters that may drop below –29$^{o}$C. Average annual precipitation is 30 centimeters and ranges from 100 centimeters in the upper mountains to less than 25 centimeters in the lower reaches. Wooded areas consist primarily of mixed fir and pine forest in the higher elevations. Sagebrush and grass communities dominate the flora in the lower elevations.

Efforts to document salmonid life histories, water quality and habitat conditions have continued in fiscal year 2001. Bull trout *Salvenlinus confluentus* are considered to be cold water species and are temperature dependant. Due to the interest of bull trout from various state and federal agencies, a workgroup was formed to develop project objectives related to bull trout. Individuals that participated in the 2001 work group are listed in table A.

Table A. List of participants and associated organization that were present for the 2001 Bull Trout Workgroup meetings.

| Organization | Participant |
|---|---|
| Burns Paiute Tribe | Lawrence Schwabe<br>Jason Fenton<br>Steve Namitz<br>Dan Gonzalez |
| Oregon Department of Fish and Wildlife | Wayne Bowers<br>Ray Perkins<br>Mary Hanson |
| Bonneville Power Administration | Peter Lofy |
| US Bureau of Land Management | Cynthia Tate<br>Cindy Weston |
| US Forest Service | Alan Miller<br>Rick Vetter<br>Jim Soupir |
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| US Bureau of Reclamation | Rick Rieber |
| US Geological Survey | Jim Petersen |

This report will reflect work completed during the Bonneville Power contract period starting 1 April 2001 and ending 31 March 2002. All tasks were conducted within this timeframe and a more detailed timeline can be referred to in each individual report.

The study area will include the Upper Malheur River from Warm Springs Reservoir upstream to the headwaters and the North Fork Malheur above Beulah Reservoir.

The project objectives for 2001 in the statement of work submitted to the Bonneville Power Administration are as follows:

Objective 1. Document the complete migratory patterns of adult/subadult bull trout in the Middle Fork Malheur Basin.

Report submitted, see report:
*Use of Radio Telemetry to Document Movements of Bull Trout in The Upper Malheur River, Oregon. 2001*

Objective 2. Determine population trends and age class structures in bull trout and redband trout in the Malheur Basin.

Report submitted, see report (s):
*Population Estimate of Salmonids in McCoy Creek 2001*
*Population Estimate of Salmonids in Summit Creek 2001*

Objective 3. Determine water quality parameters in the Middle Fork and North Fork Malheur Basins.

Report submitted, see report (s):
*Stream temperature monitoring on streams flowing through the Logan Valley wildlife mitigation property, 2001*

Objective 4. Determine the timing of spawning and preferred spawning sites.

Report submitted, see report (s):
*Bull Trout Spawning Survey Report, 2001 Malheur Fish District*

Objective 5. Determine bull trout use and entrainment at Beulah and Warm Springs Reservoirs.

Report submitted, see report (s):
*Entrainment of Bull Trout at Agency Valley Dam 2001*

Objective 6. Evaluate the habitat profile of rearing tributaries of the Middle and North Fork Malheur River.

Report not submitted. Staff is having difficulty operating Oregon Department of Fish and Wildlife's d-base program for data analysis. Data has been collected and staff is currently working with personnel from ODFW on the d-base program. Report should be expected in the 2002 annual report.

Objective 7. Determine the genetic variability of redband trout within the Middle Fork Malheur River and Warm Springs Reservoir.

Report not submitted. Genetic samples have been collected and sent to the University of Montana for genetic analysis. University of Montana will provide a report when analysis is complete.

Objective 8. Determine cold water micro-refugia within the Middle and North Fork River Basins.

Report not submitted. Tribal staff identified areas to survey in 2002. Expect report in 2002 annual report.

Objective 9. Determine adult brook trout migration patterns in the Middle Fork Malheur basin.

Report submitted, see report (s):
*Use of Radio Telemetry to Document Movements of Brook Trout in the Upper Malheur Basin in Oregon*

# Acknowledgements

Funding provided by the Bonneville Power Administration and Bureau of Reclamation made project operation possible. A special thanks is extended to the Malheur River Bull Trout Recovery Team for the technical input and time invested into the project. Members include: Raymond R. Perkins (ODFW), Wayne L. Bowers (ODFW), Rick W. Rieber (USBR), Tammy Salow (USBR), Alan J. Mauer (USFWS), Alan Miller (USFS), Jim Soupir (USFS), Cynthia K. Tait (BLM), and Brian Lampman (BLM).

# Bull Trout Spawning Survey Report

## 2001

AUTHOR: RAY PERKINS, MALHEUR FISH DISTRICT, APRIL, 2002

## Introduction

Prior to 1992 bull trout (*Salvelinus confluentus*) were known to exist in the North Fork and in the upper Malheur River watersheds. In 1992, with increasing interest in the status of bull trout ODFW began spawning surveys in the North Fork Malheur River watershed. We hoped spawning surveys would give us the ability to track trends in spawning bull trout abundance. The North Fork watershed was selected for initial surveys because it would be simpler to understand bull trout spawning without the presence of brook trout (*Salvelinus fontinalis*).

ODFW district staff and volunteers did surveys in 1992. Since then additional cooperators have assisted with the surveys. Present survey participants include ODFW, Malheur National Forest, U. S. Fish and Wildlife Service, Burns Paiute Tribe, Bureau of Land Management, and a number of volunteers. This report summarizes data collected through 2001.

From 1992 through 1996 many different stream reaches were walked in the hopes of finding bull trout redds. To select stream reaches to be walked we used data from the stream habitat survey and a population estimate completed in1991-2 in tributaries of the upper North Fork. Stream reaches were walked in mid-September and mid-October. In 1997 stream reaches were walked in late August for the first time. Since 1997 stream reaches have been walked three times, late August, Mid-September, and late September. Since 1997, Horseshoe Creek is the only new stream reach walked where redds were observed.

Redd counts were begun in the Upper Malheur River watershed in 1998. As with the North Fork watershed, a stream habitat survey and population estimate completed in 1994 in Meadow Fork, Snowshoe, Big, and Lake creeks was used to select the initial stream reaches to be walked. Since then, we have added and dropped stream reaches in lower Summit and Bosonberg creeks and added stream reaches in Big and Summit creek.

Currently we believe that the core bull trout spawning areas are being surveyed. Stream sections may be extended or added in the future to incorporate new information.

The main objectives for this study are:

1. Determine where bull trout spawn.
2. Determine when bull trout spawn.
3. Determine the number of spawning bull trout.
4. Determine the location and timing of brook trout spawning in relation to bull trout spawning in the Upper Malheur River Watershed.
5. Estimate time spent on redd construction.
6. Estimate the number of redds a pair might dig.

The first three objectives apply to both watersheds. The fourth objective applies specifically to the Upper Malheur River watershed and is an effort to separate bull trout spawning from brook trout spawning. The fifth and sixth objectives were added in 1999 in order to determine how many adults are associated with a single redd and possible how much time an adult might spend on the spawning grounds. Therefore, allowing us to better estimate the number of spawning adults in the populations. Currently objectives 5 and 6 are being investigated only in upper Little Crane Creek.

# Methods

Spawning surveys were completed on streams in the North Fork Malheur and Upper Malheur watershed streams known or suspected to support bull trout spawning. Stream reaches were surveyed on 29-31 August, 12-14 September, and 26-28 September. A fourth spawning survey was completed on streams in the Upper Malheur River watershed on 10 October. Two or more people surveyed each stream reach in an upstream direction with at least one experienced surveyor per team. Usually the surveyor walked on opposite sides of the stream. Crews counted redds, recorded numbers of bull trout seen, and estimated total length (inches). All redds, except for the last survey, were flagged to avoid double counting on subsequent surveys.

Each crew used a GPS unit to record locations at the start and end of each stream section; redds; and positively identified bull trout. GPS readings were transferred to data sheets manually during surveys. Each GPS unit was set to record coordinates in decimal degrees or decimal minutes and used NAD 1983. All GPS coordinates were entered into Arcview 3.1 and mapped. Attempt was made to correct for GPS unit or recording errors when points were mapped.

In the Upper Malheur Watershed distinguishing the difference between bull trout and brook trout redds is impossible without identifying the fish creating each redd. Very few fish were identified to species and associated with redd. Redds enumerated and mapped in the upper Malheur watershed are an aggregate of both species. The mid-October survey in the upper Malheur watershed is an attempt to differentiate peak spawning times between bull trout and brook trout.

In order to estimate how many redds a bull trout pair might build and the amount of time a pair would spend on a redd Little Crane Creek was walked three consecutive days during the first survey period in late August. Each day, redd and bull trout locations were noted. Later the locations of bull trout with similar descriptions (length) were compared between days.

# Results

## North Fork Malheur River Watershed

### North Fork Malheur River

The upper North Fork Malheur was surveyed three times. The survey began at the mouth of Deadhorse Creek and ended 2.9 miles upstream (Appendix Figure A-1). The upper half-mile of stream was not walked during first two surveys because of warm water temperatures nor on the third survey because of low stream flows. A short section (~0.1 mile) of the North Fork just upstream of Forest Road 16 bridge was walked two times.

No redds and three bull trout were observed on 28 August, three redds and three bull trout were observed on 11 September, and two redds and no bull trout were observed on 26 September (Table 1). No bull trout or redds were observed in the lower section.

Table 1. Bull trout redds observed in the mainstem of the North Fork Malheur River.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1992[a] | 1 | 5.9 | 0.2 |
| 1993 | 1 | 15.5 | 0.1 |
| 1994 | 0 | 7.3 | 0.0 |
| 1995 | 0 | 6.0 | 0.0 |
| 1996 | 6 | 3.9 | 1.5 |
| 1997 | 10 | 2.3 | 4.4 |
| 1998 | 3 | 3.8 | 0.8 |
| 1999 | 9 | 3.5 | 2.6 |
| 2000 | 16 | 3.5 | 4.3 |
| 2001 | 5 | 3.0 | 1.7 |

[a]- Does not include 14 questionable redds observed by volunteers included in earlier reports.

## Horseshoe Creek

Horseshoe Creek was surveyed three times. The survey began at the confluence with North Fork Malheur River and ended about 0.6 miles upstream (Appendix Figure A-1). Three redds and one bull trout were observed on 28 August, two redds and no bull trout were observed on 11 September, and one redd and no bull trout were observed on 25 September (Table 2).

Table 2. Bull trout redds observed in Horseshoe Creek, tributary to North Fork Malheur River.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1998 | 4 | 0.4 | 10.0 |
| 1999 | 4 | 0.8 | 5.0 |
| 2000 | 7 | 0.8 | 6.3 |
| 2001 | 6 | 0.6 | 10.3 |

## Deadhorse Creek

Deadhorse Creek was surveyed three times. The survey began at the confluence with North Fork Malheur River and ended about 0.3 miles upstream at Forest Road 13 (Appendix Figure A-1). No redds or bull trout were observed on any of the surveys (Table 3).

Table 3. Bull trout redds observed in Deadhorse Creek, tributary to North Fork Malheur River.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1999 | 0 | 0.8 | 0.0 |
| 2000 | 0 | 0.8 | 0.0 |
| 2001 | 0 | 0.8 | 0.0 |

## Flat Creek

Flat Creek was surveyed three times. The survey began at the confluence of North Fork Malheur River and ended about 0.2 miles upstream (Appendix Figure A-2). ). No redds or bull trout were observed on any of the surveys.

## Spring Creek

Spring Creek was surveyed three times. The survey began at the confluence with the North Fork Malheur River and ended about 0.25 miles upstream (Appendix Figure A-2). ). No redds or bull trout were observed on any of the surveys.

## Swamp Creek

Upper Swamp Creek was surveyed three times (Appendix Figure A-2). Three redds and seven bull trout were observed on 29 August, 14 redds and four bull trout were observed on 12 September, and four redds and no bull trout were observed on 26 September (Table 4).

Lower Swamp was surveyed three times in 2001 (Appendix Figure A-2). No redds or bull trout were observed on 29 August and 26 September. One redd and no bull trout were observed on 12 September. (Table 4).

Table 4. Bull trout redds observed in Swamp Creek, tributary to North Fork Malheur River.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1992 | 0 | 1.2 | 0.0 |
| 1993 | 3 | 2.2 | 1.4 |
| 1994 | 9 | 3.9 | 2.3 |
| 1995 | 0 | 3.9 | 0.0 |
| 1996 | 8 | 3.8 | 2.1 |
| 1997 | 21 | 4.1 | 5.1 |
| 1998 | 24 | 4.2 | 5.7 |
| 1999 | 35 | 4.1 | 8.5 |
| 2000 | 40 | 4.1 | 9.8 |
| 2001 | 22 | 4.2 | 5.3 |

## Sheep Creek

The Sheep Creek survey was divided into two sections for the first time this year. The lower survey began at the mouth and ended about two miles upstream. The upper section began at the two-mile mark and ended about 2 miles upstream. Upper Sheep Creek was surveyed three times (Appendix Figure A-2). One redd and 18 bull trout were observed on 28 August, three redds and six bull trout were observed on 11 September, and one redd and four bull trout were observed on the 25 September (Table 5). Lower Sheep Creek was surveyed three times (Appendix Figure A-2). Two redds and nine bull trout were recorded on 28 August, two redds and one bull trout were observed on 12 September, and six redds and no bull trout were observed on 26 September (Table 5).

Table 5. Bull trout redds observed in Sheep Creek, tributary to North Fork Malheur River.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1992 | 0 | 1.1 | 0.0 |
| 1993 | 0 | 2.2 | 0.0 |
| 1994 | 0 | 2.2 | 0.0 |
| 1995 | 2 | 2.9 | 0.7 |
| 1996 | 13 | 3.4 | 3.8 |
| 1997 | 8 | 2.9 | 2.8 |
| 1998 | 17 | 3.5 | 4.9 |
| 1999 | 22 | 3.0 | 7.3 |
| 2000 | 25 | 4.0 | 6.3 |
| 2001 | 15 | 3.5 | 4.3 |

## Cow Creek

Cow Creek was surveyed twice (Appendix Figure A-2). This section began at the confluence with the North Fork Malheur River and ended 1.7 miles upstream. No redds or bull trout were observed on any of the surveys.

## Little Cow Creek

Little Cow Creek was surveyed twice (Appendix Figure A-2). This section began at the confluence with Cow Creek and ended about 0.8 miles upstream. No redds or bull trout were observed on any of the surveys.

## Elk Creek

Elk Creek was surveyed three times (Appendix Figure A-3). The lower section started at the confluence with North Fork Malheur River and ended upstream 1.0 miles at North Fork and South Fork confluence. No redds or bull trout were observed on any of the surveys (Table 6). North Fork Elk Creek was surveyed three times in 2001. The section began at the confluence of the North and South Forks and ended upstream 1.5 mile. One redd and three bull trout were observed on 29 August, One redd and three bull trout were observed on 12 September, no redds or bull trout were observed on 26 September (Table 6). South Fork Elk Creek was surveyed three times. This section began at the confluence of the North and South forks and ended 0.7 miles upstream. One redd and one bull trout were observed on 29 August, no redds or bull trout were observed on any of the subsequent surveys (Table 6).

Table 6. Bull trout redds observed in Elk Creek and its two tributaries, the North and South forks.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1992 | 1 | 1.0 | 1.0 |
| 1993 | 1 | 2.3 | 0.4 |
| 1994 | 0 | 2.0 | 0.0 |
| 1995 | 1 | 4.0 | 0.3 |
| 1996 | 3 | 4.1 | 0.7 |
| 1997 | 9 | 4.1 | 2.2 |
| 1998 | 6 | 3.5 | 1.7 |
| 1999 | 12 | 3.0 | 4.0 |
| 2000 | 5 | 3.0 | 1.7 |
| 2001 | 3 | 3.2 | 0.9 |

## Crane Creek

Crane Creek was not surveyed this year.

## Little Crane Creek

Upper Little Crane Creek was surveyed five times (Appendix Figure A-4). The section started at the 16 road and ended about 1.5 miles upstream at the 1665-0498 road. The stream section was surveyed each day during the first week of surveys. Fifteen redds and eight bull trout were observed on 28 August, three new redds were observed on the 29 August, an additional seven redds were observed on 30 August. Thirty-three new redds and 37 bull trout were observed on 11 September. Fifteen redds and 18 bull trout were observed on 26 September (Table 7).

Lower Little Crane Creek was surveyed three times (Appendix Figure A-5). The section began at the confluence of Little Crane and Crane creeks and ended at Forest Road 16. No redds or bull trout were observed on 28 August, no redds and two bull trout were observed on 11 September, and one redd and no bull trout were observed on 26 September (Table 7).

Table 7. Bull trout redds observed in Little Crane Creek, tributary to North Fork Malheur.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1992 | | | |
| 1993 | 3 | 5.6 | 0.5 |
| 1994 | 4 | 7.5 | 0.5 |
| 1995 | 6 | 6.0 | 1.0 |
| 1996 | 8 | 6.0 | 1.3 |
| 1997 | 16 | 4.2 | 3.8 |
| 1998 | 20 | 6.0 | 3.3 |
| 1999 | 33 | 6.1 | 5.4 |
| 2000 | 60 | 6.1 | 9.8 |
| 2001 | 74 | 6.2 | 12.0 |

## Bull Trout Observations

Beginning in 1999 number and location of bull trout were recorded during the redd counts. The number of bull trout observed during the North Fork surveys was lower than previous years (Table 8). Fish were difficult to see under blue skies and bright sun conditions. As in past years, most of the large (>16 inches) bull trout were seen on the 29-31 August survey, although, several larger (>16 inches) bull trout were observed during the September 26-28 survey.

Table 8. Number of bull trout observed during spawning surveys on the North Fork Malheur River.

| STREAM | 1999 | 2000 | 2001 | TOTAL |
|---|---|---|---|---|
| L. Crane Cr. | 95 | 125 | 65 | **285** |
| Swamp Cr. | 48 | 66 | 16 | **130** |
| Sheep Cr. | 43 | 41 | 42 | **126** |
| Horseshoe Cr. | 2 | 0 | 1 | **3** |
| Upper N. F. | 12 | 11 | 0 | **23** |
| Elk Cr. | 18 | 24 | 9 | **51** |
| Deadhorse Cr. | 0 | 0 | 0 | **0** |
| Flat Cr. | 0 | | 0 | **0** |
| Spring Cr. | | | 0 | **0** |
| Cow Cr. | | 5 | 0 | **5** |
| L. Cow Cr. | | 0 | 0 | **0** |
| **Total** | **218** | **272** | **133** | **623** |

## Bull Trout Observed On Redds

In the North Fork Malheur watershed a total of 21 redds (17%) had bull trout present. Bull trout were present on redds during the first pass (28-30 August) and third pass (26-28 September), averaging 2.3 bull trout per redd, a density similar to the last two years. This year this analysis was not conducted on Upper Malheur data due to low numbers of fish observed and poor viewing.

## Upper Malheur River Watershed

### Summit Creek

Upper Summit Creek was surveyed four times (Appendix Figure B-1). This section began at a fence downstream of 1600-0598 road and ended upstream about 1.9 miles. No redds or bull trout were observed on 30 August, 50 redds and no bull trout were observed on 13 September, and 37 redds and no bull trout were observed on 26 September (Table 9). Sixty-five redds and no bull trout were observed on 10 October.

Table 9. Redds observed in Summit Creek, tributary to Upper Malheur River, from late August-late September.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1999 | 18 | 2.3 | 7.8 |
| 2000 | 43 | 4.8 | 9.0 |
| 2001 | 87 | 1.9 | 45.8 |

### Snowshoe Creek

Snowshoe Creek was surveyed four times (Appendix Figure B-2). The section began at the confluence of Snowshoe and Big creeks and ended about 1.7 miles upstream. Two redds and no bull trout were observed on 29 August, two redds and no bull trout were observed on 13 September, and twelve redds and no bull trout were observed on 28 September (Table 10). Sixteen redds and no bull trout were observed on 10 October.

Table 10. Redds observed in Snowshoe Creek, tributary to Big Creek, from late August-late September.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1998 | 10 | 1.7 | 5.9 |
| 1999 | 25 | 1.7 | 14.7 |
| 2000 | 3 | 1.7 | 1.8 |
| 2001 | 16 | 1.7 | 9.4 |

### Big Creek

Lower Big Creek was surveyed four times (Appendix Figure B-3). The section began at the 16 road and ended at the 1648 road. No redds or bull trout were observed on 30 August, no redds or bull trout were observed on 13 September, and twenty redds and one bull trout were observed on 27 September (Table 11). Five redds and no bull trout were observed on 12 October.

Upper Big Creek was surveyed three times in 2000 (Appendix Figure B-3). The section began at the 1648 road and ended slightly upstream of the confluence with Snowshoe Creek. One redd and two bull trout were observed on 30 August, seven redds and no bull trout were observed on 13 September, and three redds and no bull trout was observed on 27 September (Table 11).

Table 11. Redds observed in Big Creek, tributary to Upper Malheur River, from late August-late September.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1998 | 0 | 2.3 | 0.0 |
| 1999 | 8 | 4.6 | 1.7 |
| 2000 | 22 | 4.6 | 4.8 |
| 2001 | 31 | 5.2 | 5.9 |

## Meadow Fork Big Creek

Lower Meadow Fork was surveyed three times (Appendix Figure B-4). The section began at the confluence with Big Creek and ended upstream at the trailhead. One redd and no bull trout were observed on 30 August, five redds and two bull trout on 12 September, and 21 redds and no bull trout were observed on 26 September (Table 12).

Upper Meadow Fork was surveyed three times (Appendix Figure B-4). The section began at the trailhead and ended upstream about 2 miles at the waterfall. Six redds and 29 bull trout were observed on 30 August, twelve redds and nine bull trout were observed on 12 September, and 47 redds and four bull trout were observed on the 26 September (Table 12). A forth survey was not conducted this year because the project coordinator forgot to tell the surveys to leave the ribbons up after the third survey.

Table 12. Redds observed in Meadow Fork Big Creek, tributary to Big Creek, from late August-late September.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1998 | 39 | 3.3 | 11.8 |
| 1999 | 25 | 3.3 | 7.6 |
| 2000 | 51 | 3.3 | 14.8 |
| 2001 | 92 | 3.2 | 28.9 |

## Lake Creek

Lower Lake Creek was surveyed four times (Appendix Figure B-5). The section started at the 1648 road and ended at the trailhead. One redd and one bull trout were observed on 29 August, four redds and one bull trout were observed on 13 September, and 23 redds and one bull trout were observed on 27 September (Table 12). Twenty-seven redds and no bull trout were observed on 10 October.

Upper Lake Creek was surveyed four times (Appendix Figure B-5). The section started at the trailhead and ended about two miles upstream at a 30-foot waterfall. Two redds and one bull trout were observed on 29 August, four redds and one bull trout were observed on 13 September, and 10 redds and one bull trout were observed on 27 September (Table 13). One hundred and eighteen redds and one bull trout were observed on 10 October (Table 13).

Table 13. Redds observed in Lake Creek, tributary to Upper Malheur River, from late August-late September.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1998 | 34 | 2.1 | 16.2 |
| 1999 | 21 | 4.3 | 4.9 |
| 2000 | 22 | 4.3 | 5.1 |
| 2001 | 44 | 4.2 | 10.5 |

## Bosonberg Creek

Bosonberg Creek was not surveyed this year.

# Discussion

North Fork Malheur redd counts for the years 1992-95 were influenced by inconsistent survey techniques between years. During those years project personnel were struggling with uncertainties related to spawning timing, and location. Consequently, there was variation in timing of surveys and areas surveyed. Livestock were abundant in some spawning areas during those years making identification of redds difficult. Since 1996, survey areas and timing have been standardized. Expertise of surveyors has also increased and most are familiar with all survey sections. A change in livestock management has reduced stream disturbance and made redds more easily identifiable.

A total of 125 redds were observed in the North Fork Malheur watershed in 2001 compared to 150 redds in 2000, a decline of 17 percent (Appendix C-1, 2). Little Crane Creek, Swamp Creek, and Sheep Creek continue to be prime spawning areas for bull trout. Together these three streams contain 88.8 percent of all redds counted this year. Good spawning habitat seems to be concentrated in small areas of these three streams (Appendix Figure A-2). Spawning activity is known to occur in three other streams, but at comparably low levels.

Upper Little Crane Creek was the only stream reach with an increase in redds counted. Distribution of redds this year was very similar to redd locations in 1999 and 2000. Redd counts on Swamp Creek declined 45 percent. Distribution of redds were concentrated into the upper half of the upper stream reach. Redd counts on Sheep Creek declined 40 percent. Distribution of redds was more concentrated over the same area as in previous years. Several redds were observed upstream of previous observations. The upper North Fork Malheur River reach had the greatest decline in redds counted in the watershed, 63 percent. All redds were observed in a short section of stream between a large boggy meadow near River 58 and Forest Road 1370 near River Mile 55 (Appendix A Figure 3). In previous years, redds and fish were documented as far upstream as the headwater spring at River Mile 60. None were observed upstream of River Mile 58. This year, during the first survey period instantaneous water temperatures were recorded at several locations along the North Fork. Water temperatures downstream of River Mile 58 were close to or slightly above 10°C, which is marginal for bull trout spawning. About 200 meters upstream of River Mile 58 the water temperature rose to 15.5°C and stayed warm for several hundred meters upstream. The redd counts in Elk Creek declined 75 percent since 1999. The reason for the decline is not apparent, but is thought to be associated with possible illegal harvest associated with a campground near Forest Road 16.

Redd counts in the Upper Malheur River Watershed increased in all streams surveyed (Appendix C-Figures 3, 4). A total of 270 redds were observed in the first three surveys in 2001 compared to 160 in 2000. Summit, Meadow Fork, and Lake creeks showed the largest numeric increases and Snowshoe Creek the largest percent increase. Most of the increases in redds occurred during the third survey in late September, when a quick change in water temperature and flow conditions may have induced brook trout to spawn in a more concentrated time period. A total of

231 new redds were observed on the 10 October survey in Upper Malheur Watershed compared to 270 redds counted during the first three surveys combined. A forth survey of Meadow Fork was not completed this year because all flags used to distinguish previously identified redds were removed after the third pass in late September by mistake.

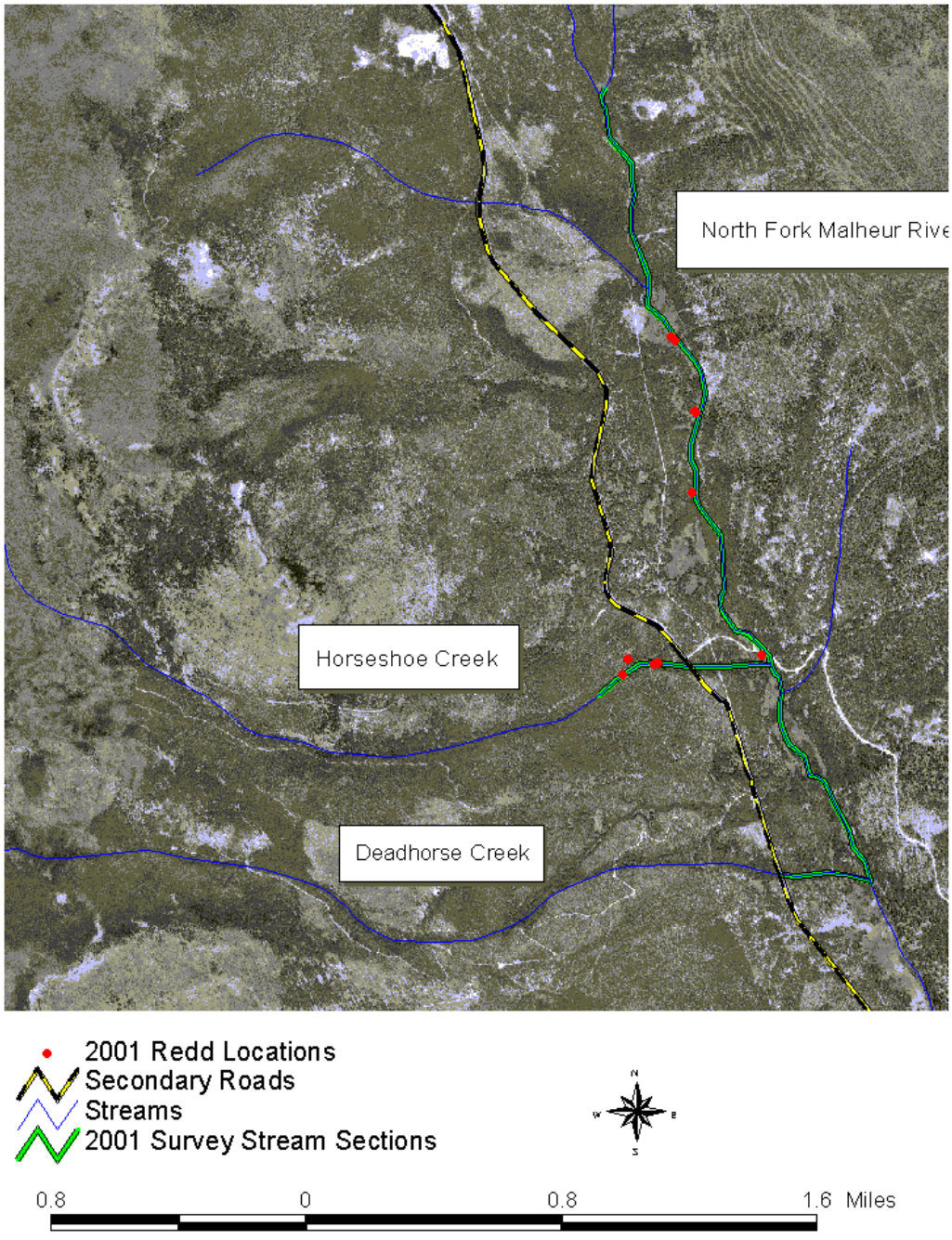
As in previous years most, 82 percent (44/54), of all bull trout were observed in Meadow Fork and 78 percent (42/54) were observed in the upper section of Meadow Fork. The next highest stream was Lake Creek (7). Meadow Fork particularly Upper Meadow Fork Creek is the last strong hold for bull trout in the upper Malheur watershed. High redd counts during the third survey period suggests that brook trout continue to impact Meadow Fork's bull trout.

2001 was the first spawning season since we began this project that these watersheds experienced drought conditions. The decrease in redds is discouraging but, at the same time, enlightening. The decline in bull trout redd in the North Fork watershed and the large increase in probable brook trout redds in September and October in the Upper Malheur watershed shows how vulnerable both populations still are. I was surprised by the magnitude of the increase in spawning activity in upper Little Crane Creek. Disappointments include the decline in redds in Elk and in the Upper North Fork. The decline in spawning activity in Elk is more likely associated with illegal human harvest. We will see over the next few years with increased law enforcement. I was more surprised by the habitat conditions (primarily water temperature fluctuations) observed in the upper North Fork.

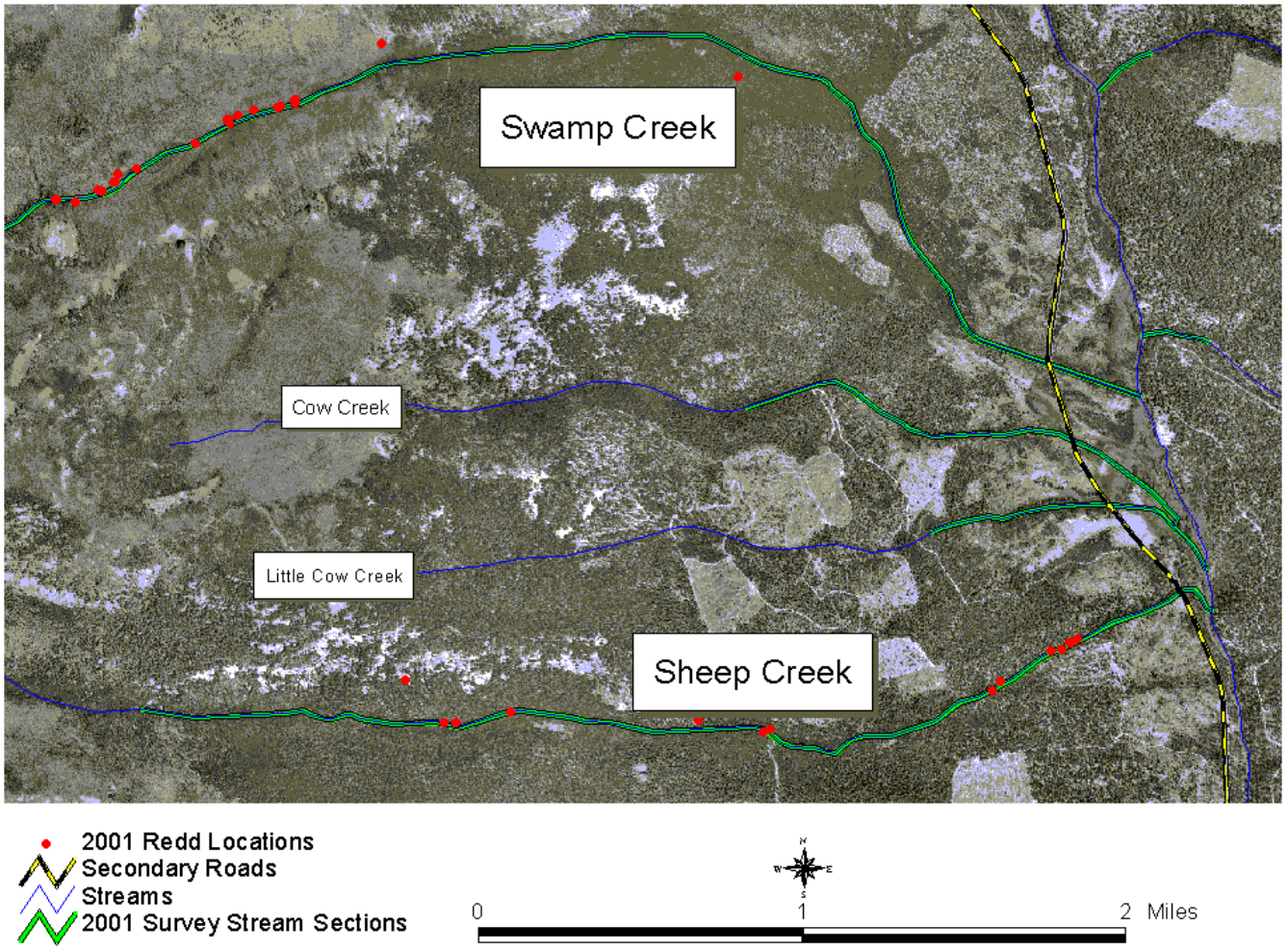
It will be interesting to see what happens in 2002. Will the numbers of larger bull trout in the North Fork decline or remains relative constant? Will there be a rebound in redds or a further erosion in the counts?

## APPENDIX A. Locations of Bull Trout Redds Observed During Spawning Surveys in the North Fork Malheur Watershed in 2001.

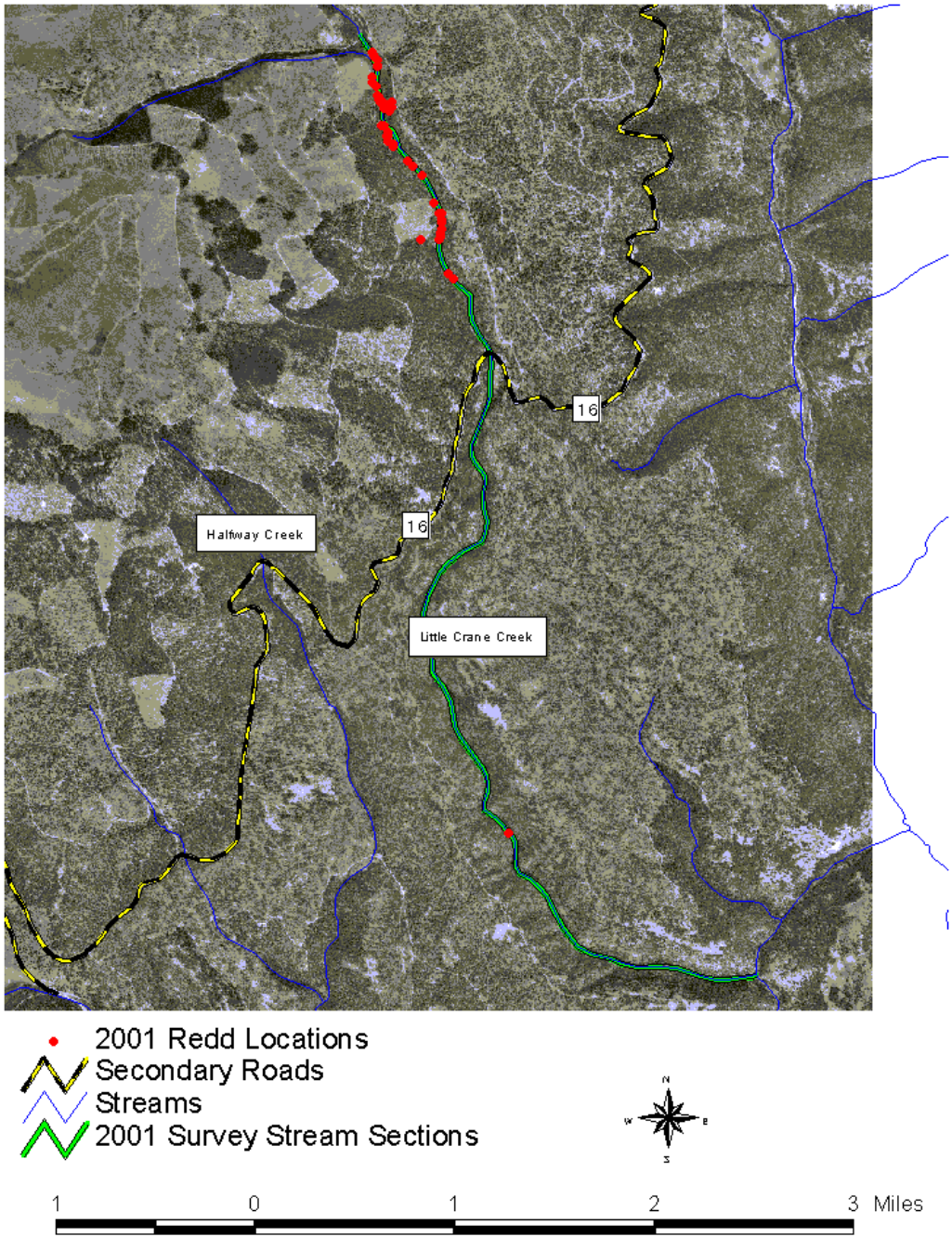
Appendix Figure A-1. Bull trout redds observed in Horseshoe, Deadhorse, and upper North Fork Malheur River stream sections in 2001.



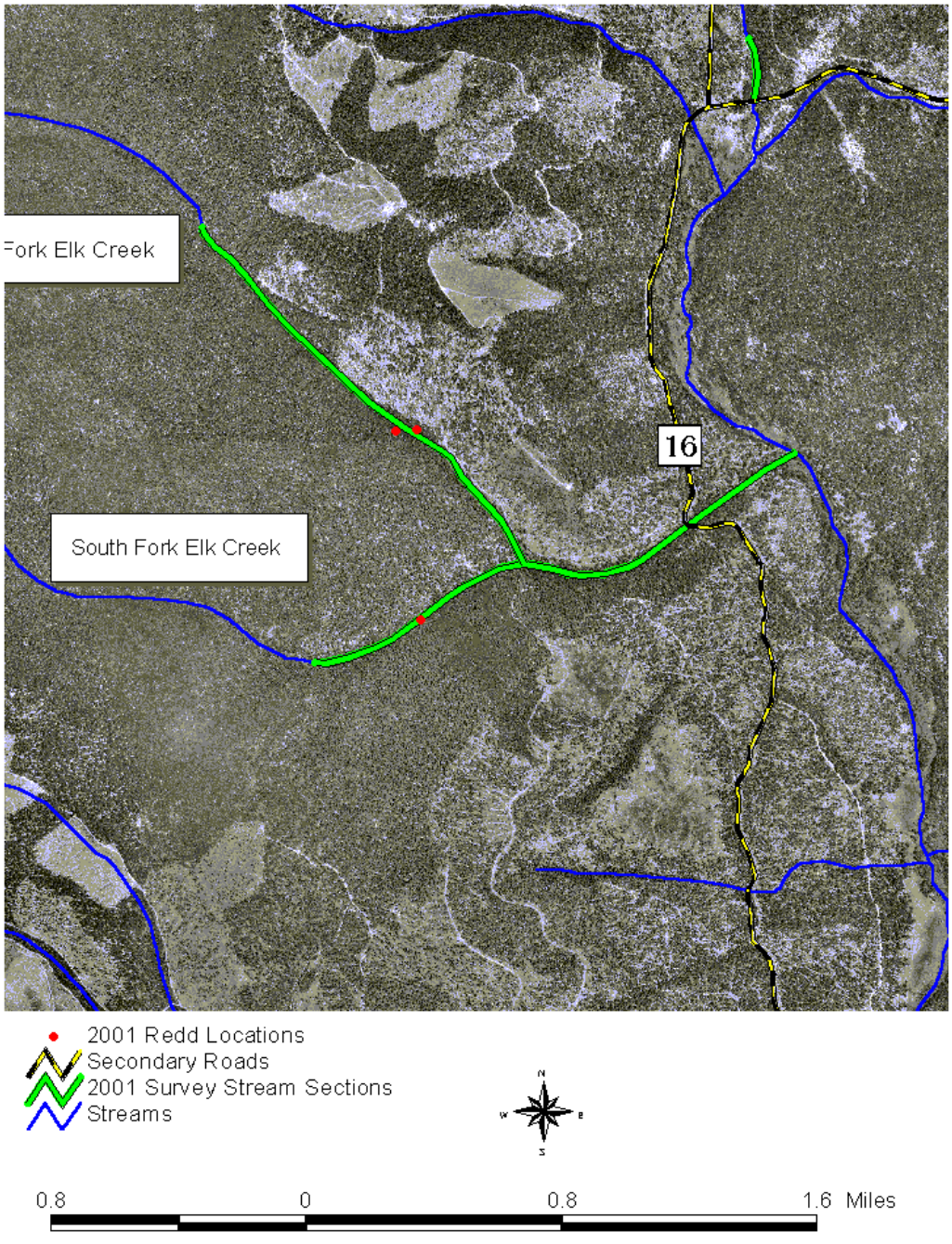
Appendix Figure A-2. Bull trout redds observed in Swamp, Cow, Little Cow, and Sheep creeks in 2001.



Appendix Figure A-3. Bull trout redds observed in Little Crane Creek stream sections in 2001.

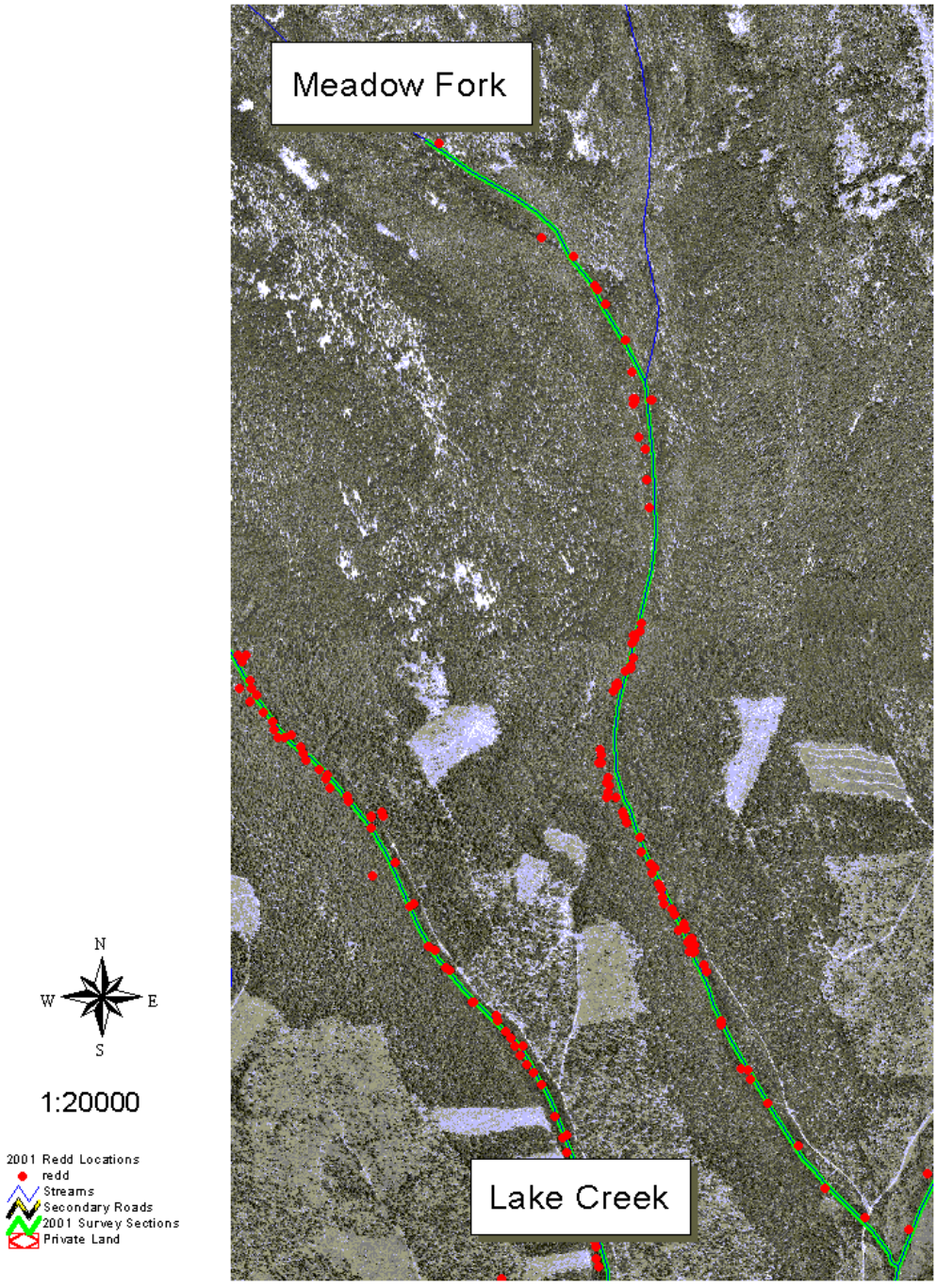


Appendix Figure A-4. Bull trout redds observed in Elk Creek stream sections in 2001.

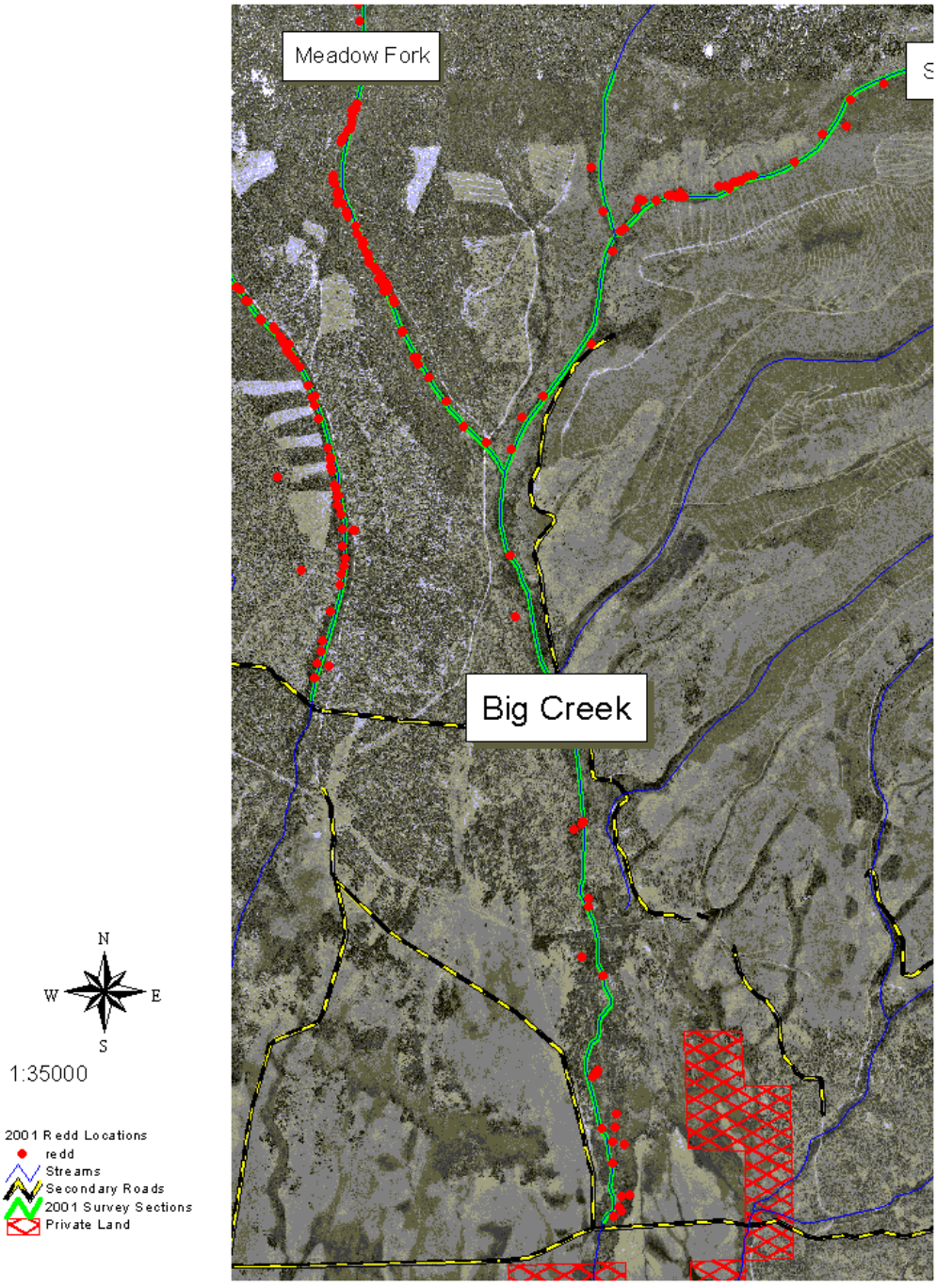


## APPENDIX B. Locations of Redds in the Upper Malheur River Watershed in Aug-Oct. 2001.

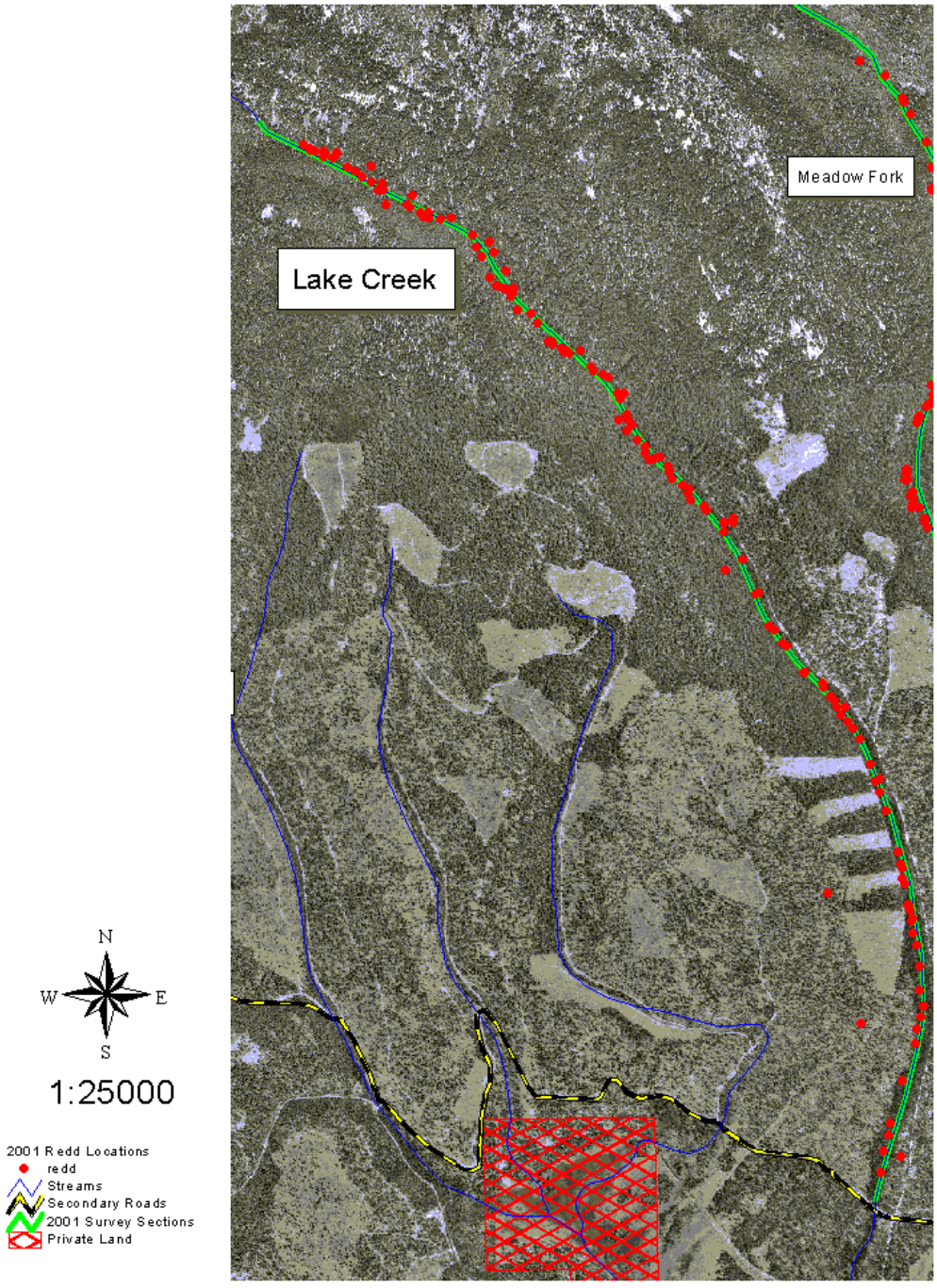
Appendix Figure B-1. Bull trout redds observed in Meadow Fork stream sections in 2001.



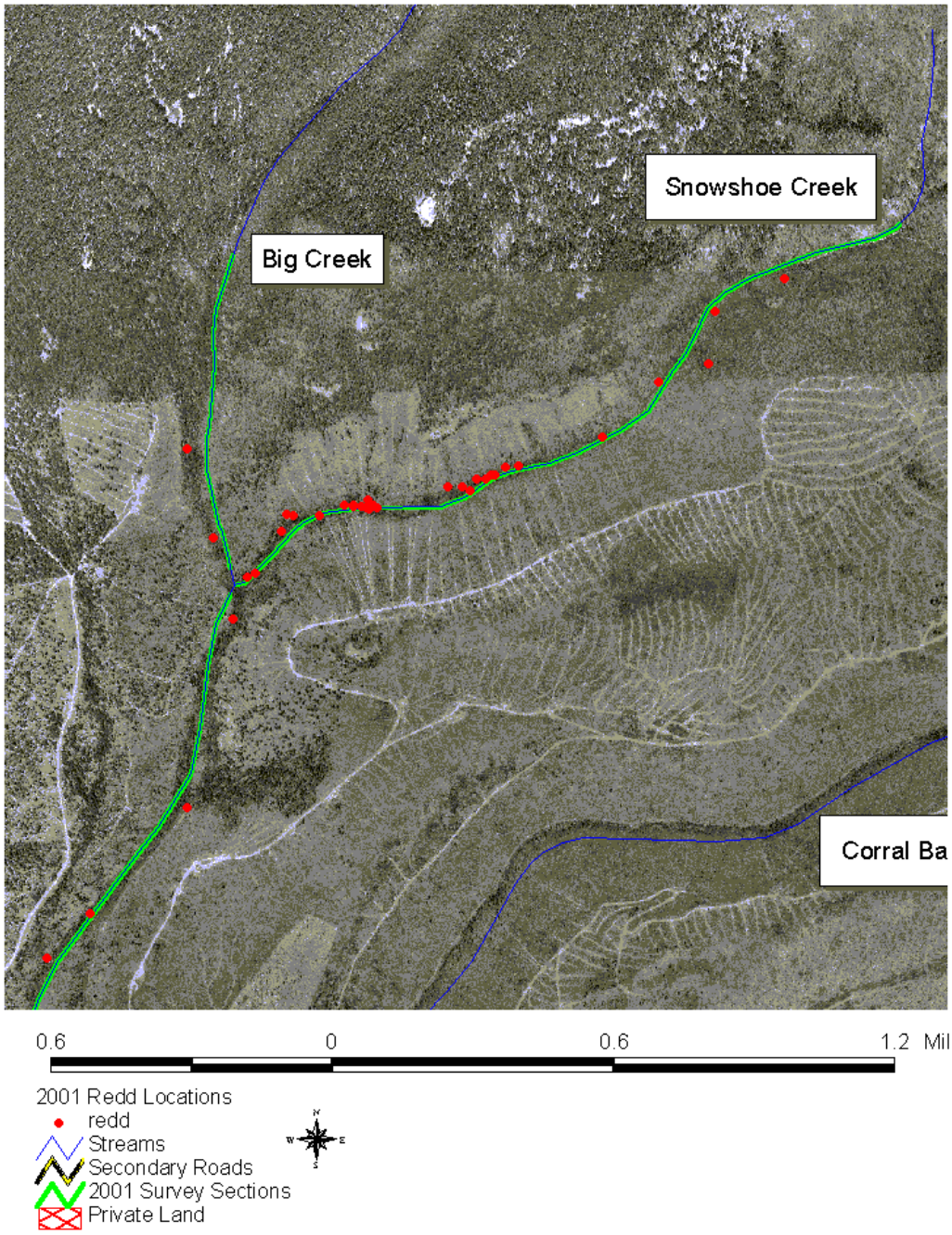
Appendix Figure B-2. Bull trout redds observed in Big Creek stream sections in 2001.



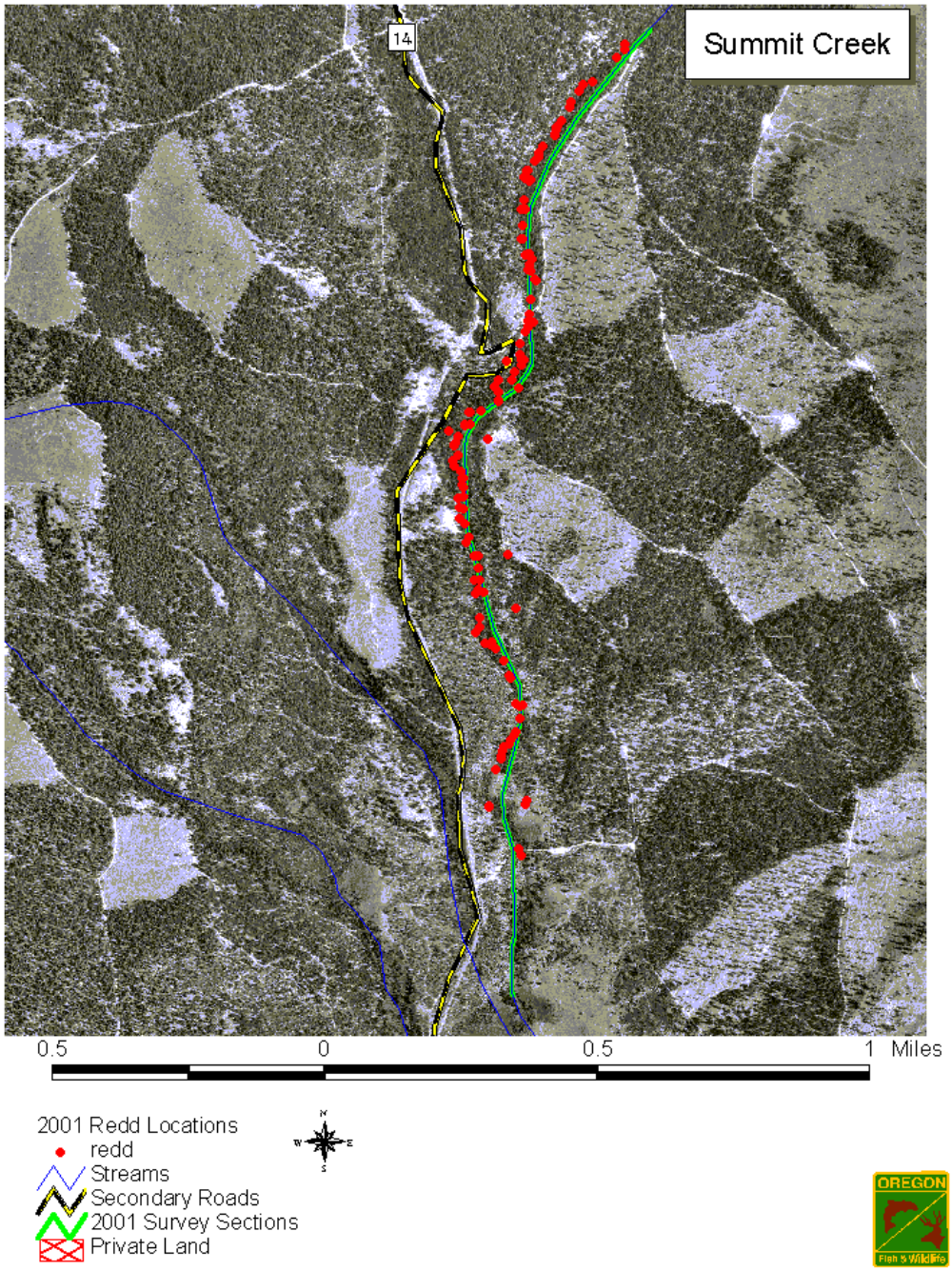
Appendix Figure B-3. Bull trout redds observed in Lake Creek stream sections in 2001.



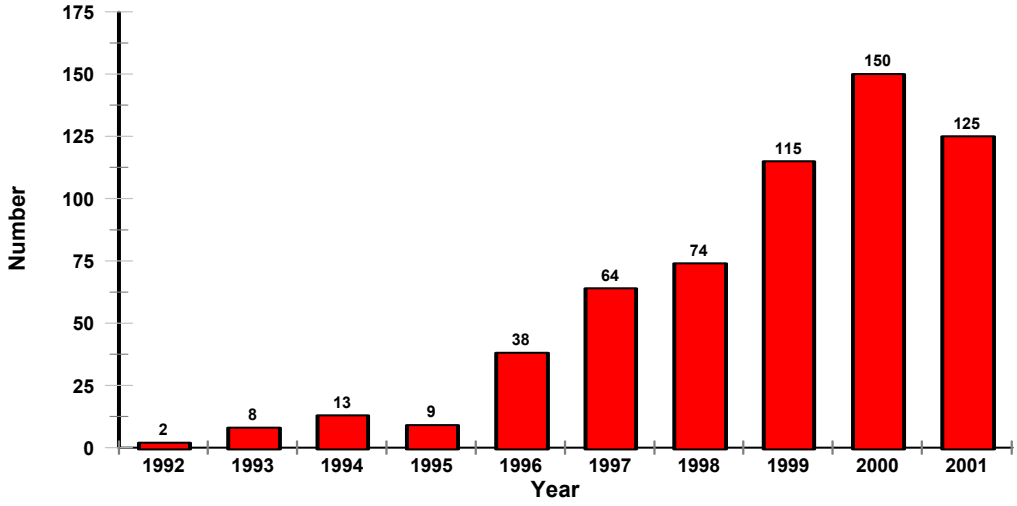
Appendix Figure B-4. Bull trout redds observed in Snowshoe Creek stream sections in 2001.



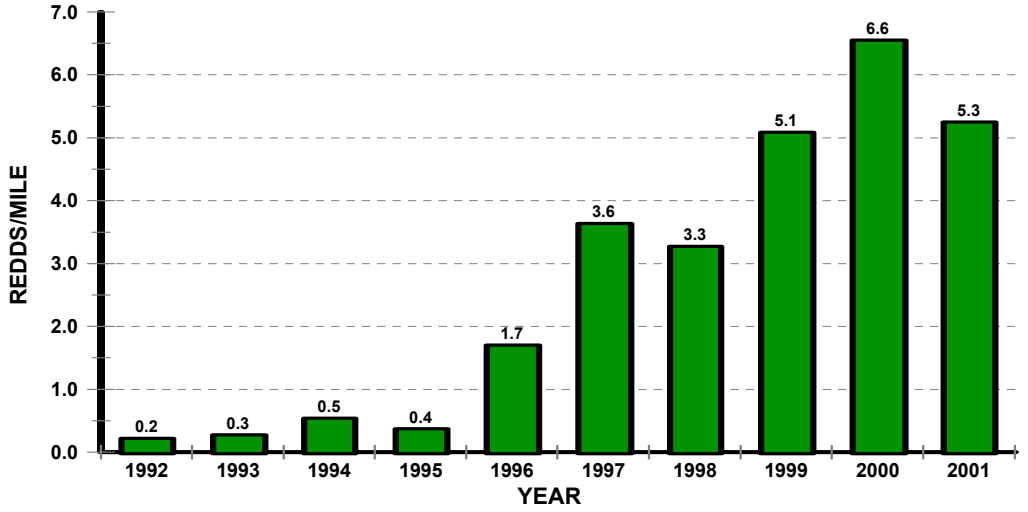
Appendix Figure B-5. Bull trout redds observed in Summit Creek stream sections in 2001.



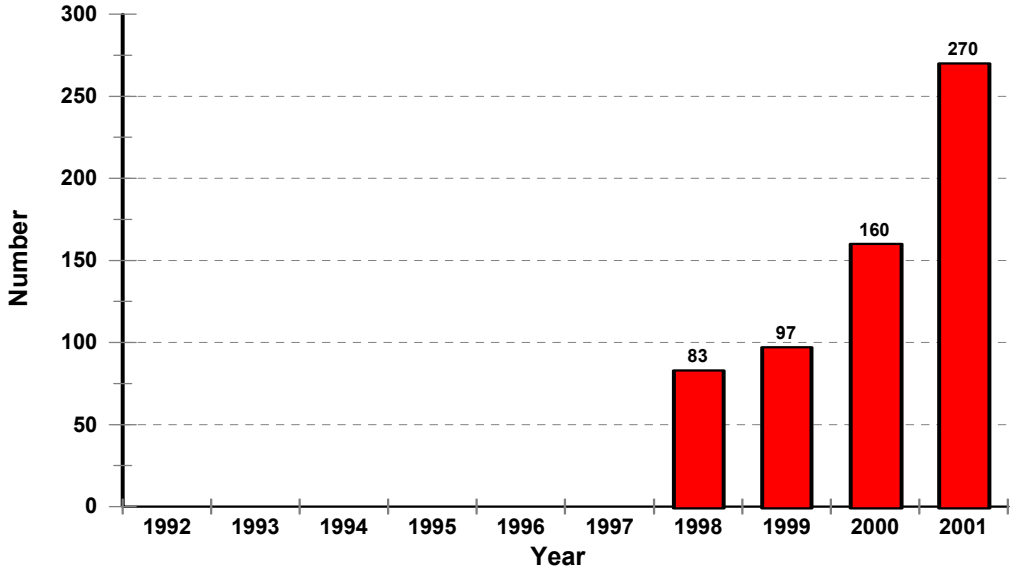
**APPENDIX C. Total redd observed in the Upper Malheur River and North Fork Malheur Watersheds from Aug-Oct. 1992-2001, Baker and Grant Counties, Oregon.**



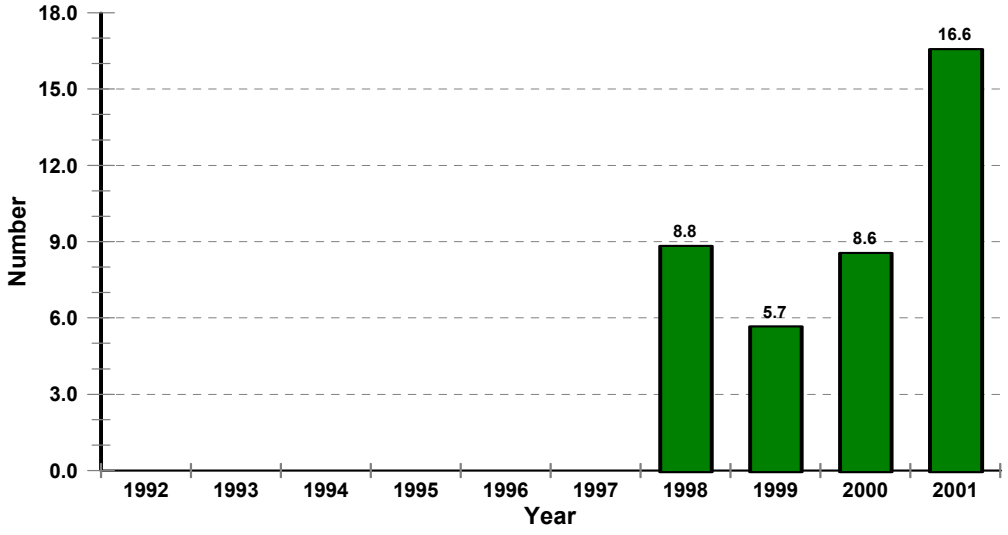

Appendix Figure C-1. The number bull trout redds observed in the North Fork Malheur River watershed from 1992-2001.




Appendix Figure C-2. The number bull trout redds per mile of stream observed in the North Fork Malheur River watershed from 1992-2001.




Appendix Figure C-3. The number of redds observed in the upper Malheur River watershed during August and September from 1998-2001.




Appendix Figure C-4. The number of redds per mile in the upper Malheur River watershed during August and September from 1998-2001.

**APPENDIX D. Comparison of bull trout redd locations during normal (1999 and 2000) and dry water years (2001) in the North Fork Malheur Watersheds from August to September.**

Spring and early summer flows in the North Fork Malheur River and tributaries were lower than average in 2001. Snowpack data from NRCS indicated spring snow-water equivalent for the basin was near half of normal. Flows in Swamp Creek were at summer low levels in late June when thermographs were deployed. Flows in the Mainstem North Fork just upstream of Crane were almost 18 inches below flow levels observed in June in 1999 and 2000.

I thought it would interesting to see if under low flow conditions I could detect a change in use patterns by spawning bull trout. The redd locations from the last three years would be used to check the question. A 100m circle was drawn around each location to represent the accuracy of each location. Redds prior to 1999 were not located with GPS so were not used. All three data sets for each stream was run through an outlier removal program, in which up to 5% were removed.

## Elk Creek

Too few data points to analyze (Appendix D-1).

## Little Crane Creek

There appears to be no distinguishable change in the pattern of use (AppendiD-2).

Upper North Fork Malheur River and Horseshoe Creek

In the North Fork there appears to be a reduction in the area of use (Appendix D-3). Redds were not observed as far upstream or downstream as in previous years. Within the area of use in 2001 redds were more concentrated into areas of ground water influence.

## Sheep Creek

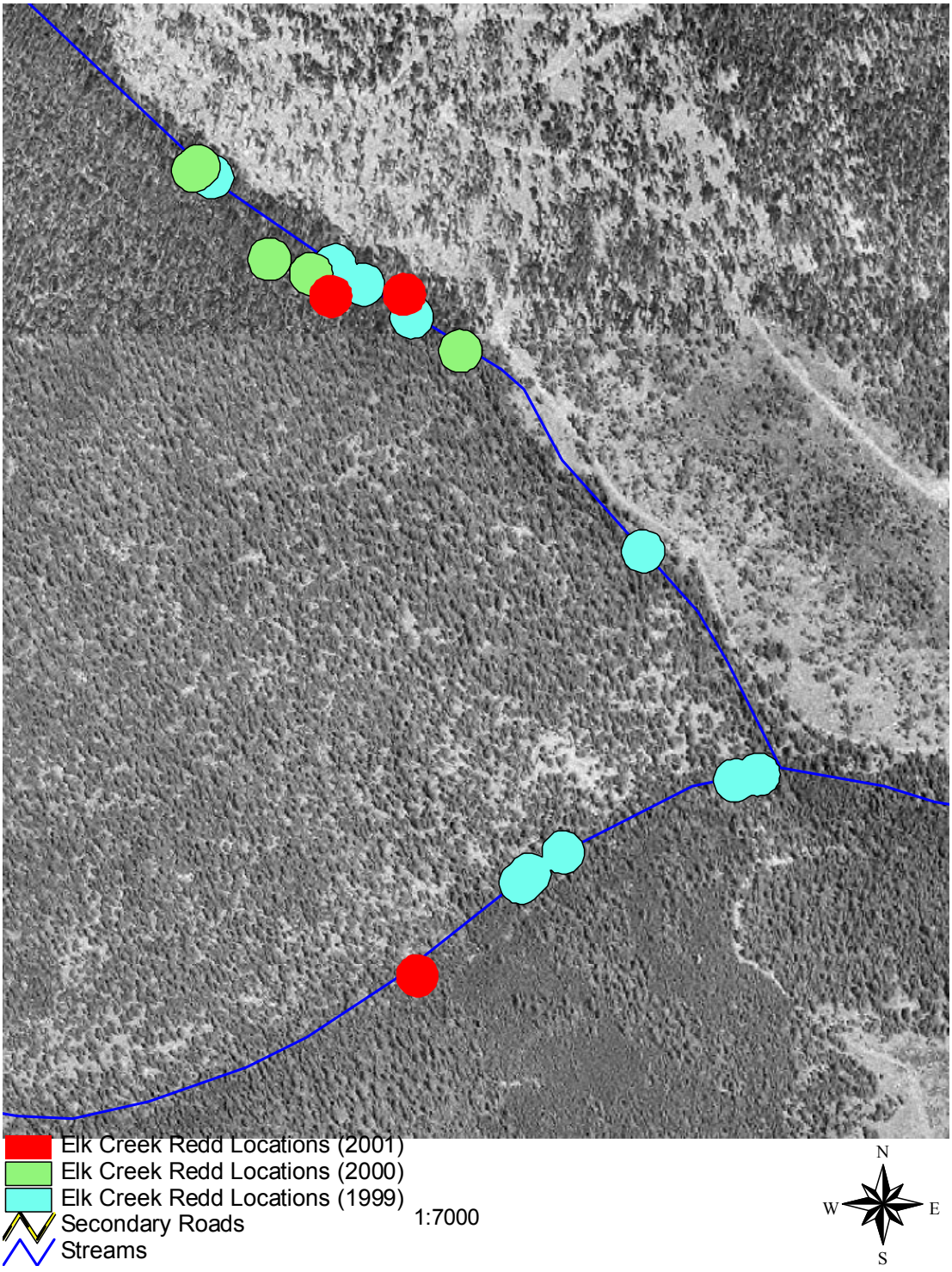
In Sheep Creek several change in the pattern of use were detected (Appendix D-4). First, in the lower third of the stream redds were more concentrated into areas with higher amount of ground water influence. Second, in the middle third of the stream three redds were observed in the same area were six were observed in 1999 and 2000. Third, four redds were observed upstream of any previous redd observations 1999 and 2000.

## Swamp Creek

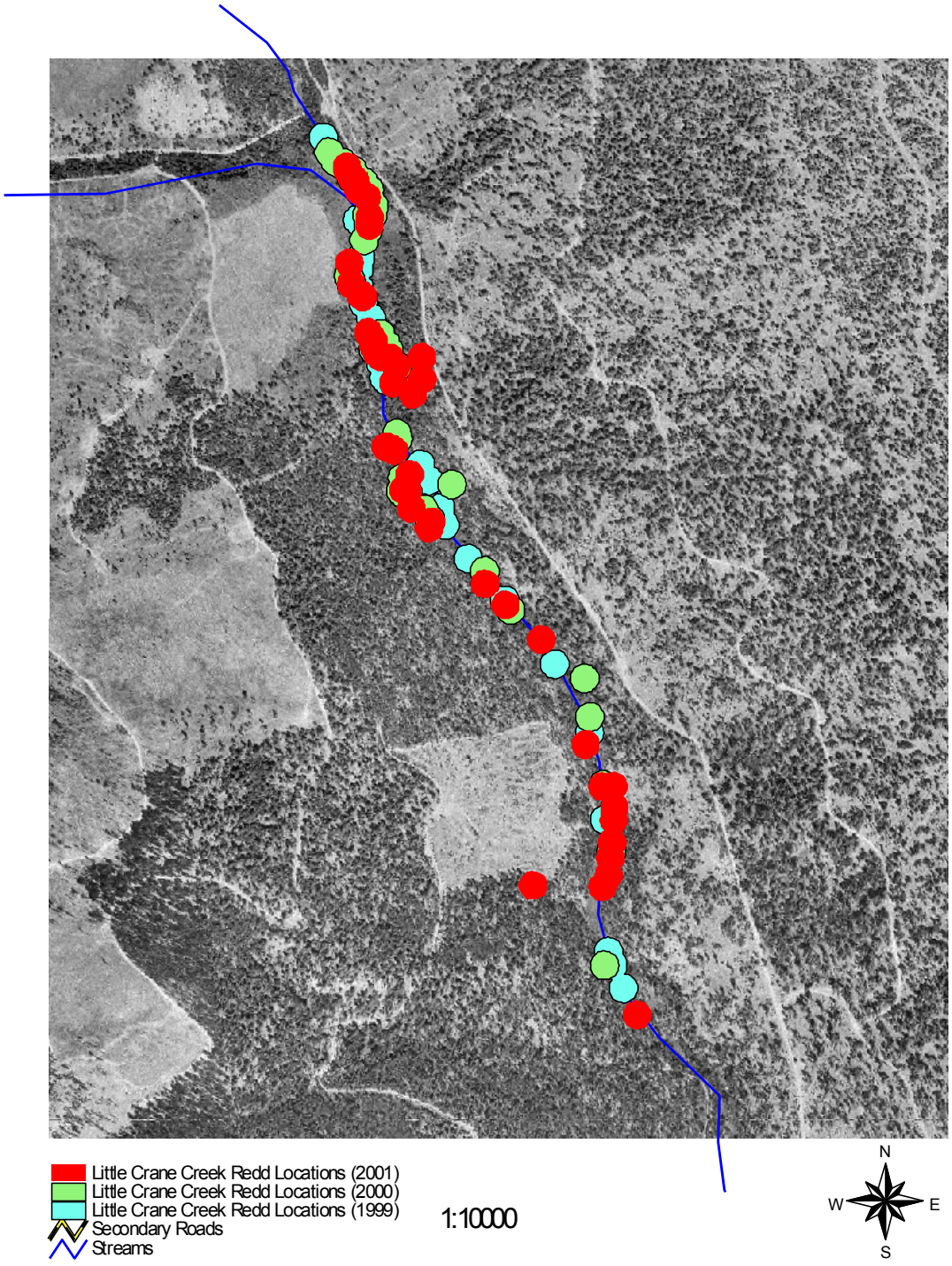
The change in pattern of use was most noticeable in Swamp Creek (Appendix D-5). In 1999 and 2000 redds were observed throughout the upper two miles of stream with a concentration at the upper end. This year redds most redds were observed in the upper end of Swamp Creek. This area has the greatest amount of ground water influence.

The overall pattern I saw this year was a move to concentrate spawning activity around areas with significant ground water influence. These areas are areas with stable flow, warmer winter water temperature and cooler summer water temperatures.

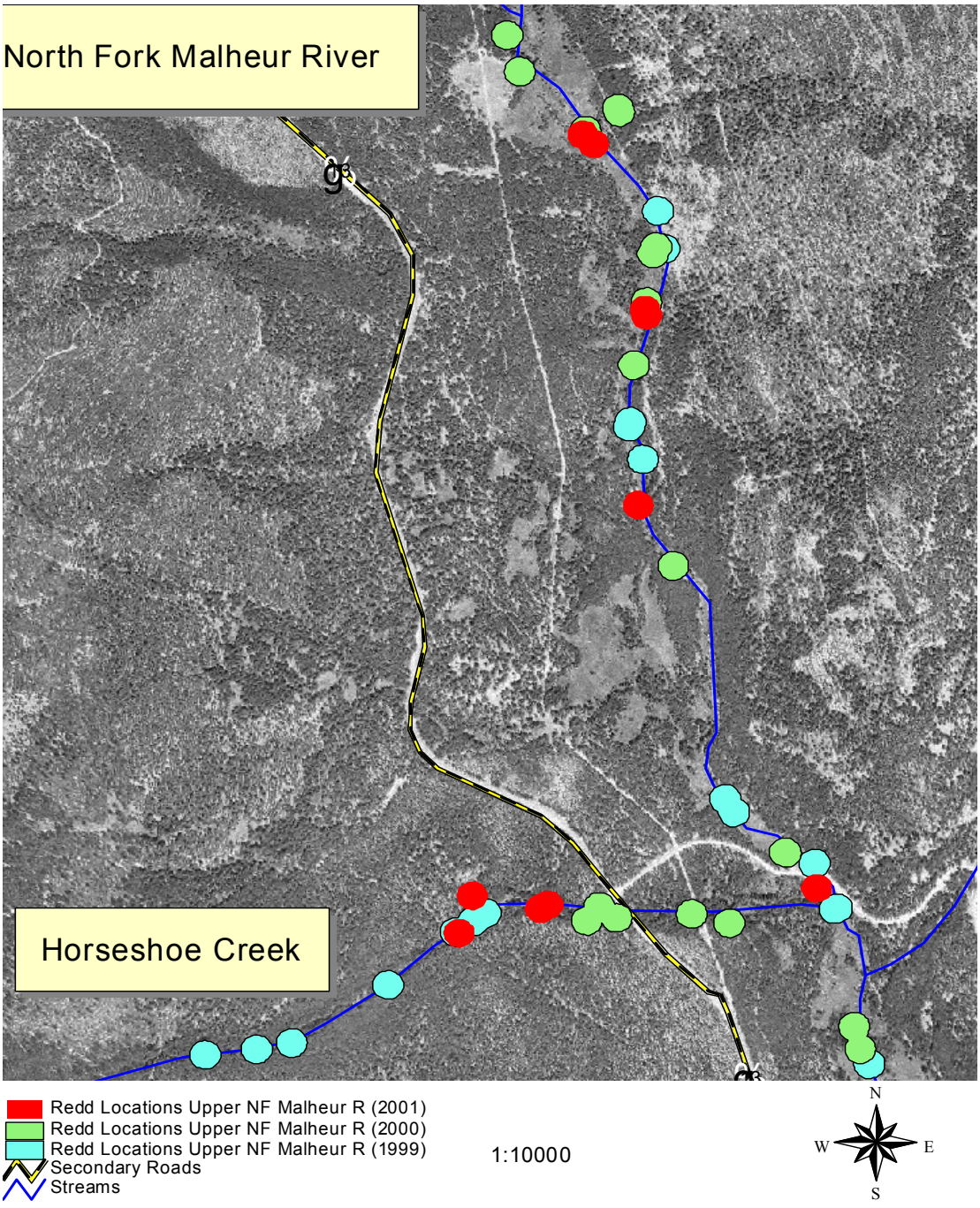
Appendix D-1. Comparison of redd locations from 1999 to 2001 in Elk Creek.



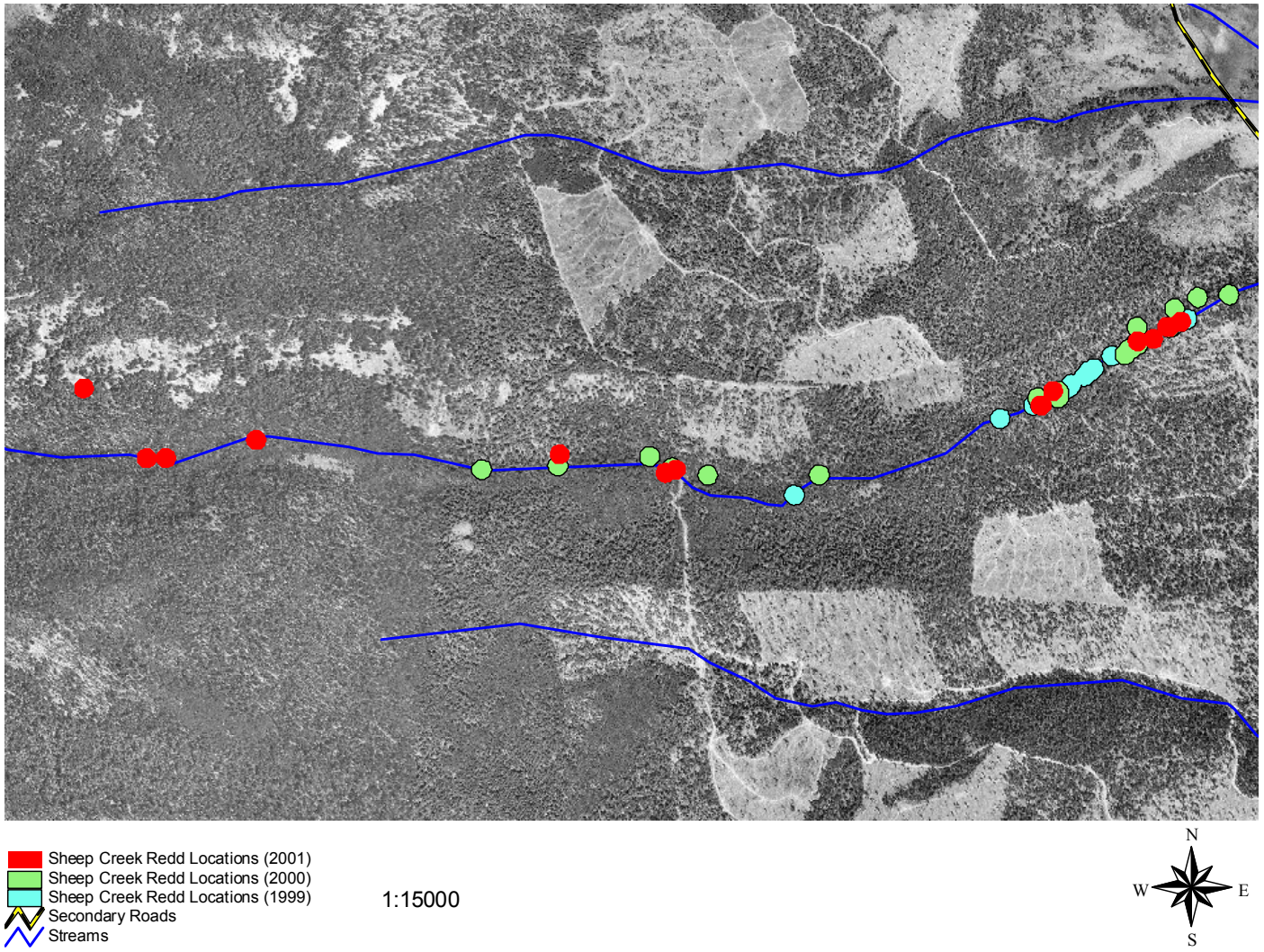
Appendix D-2. Comparison of redd locations from 1999 to 2001 in upper Little Crane Creek.



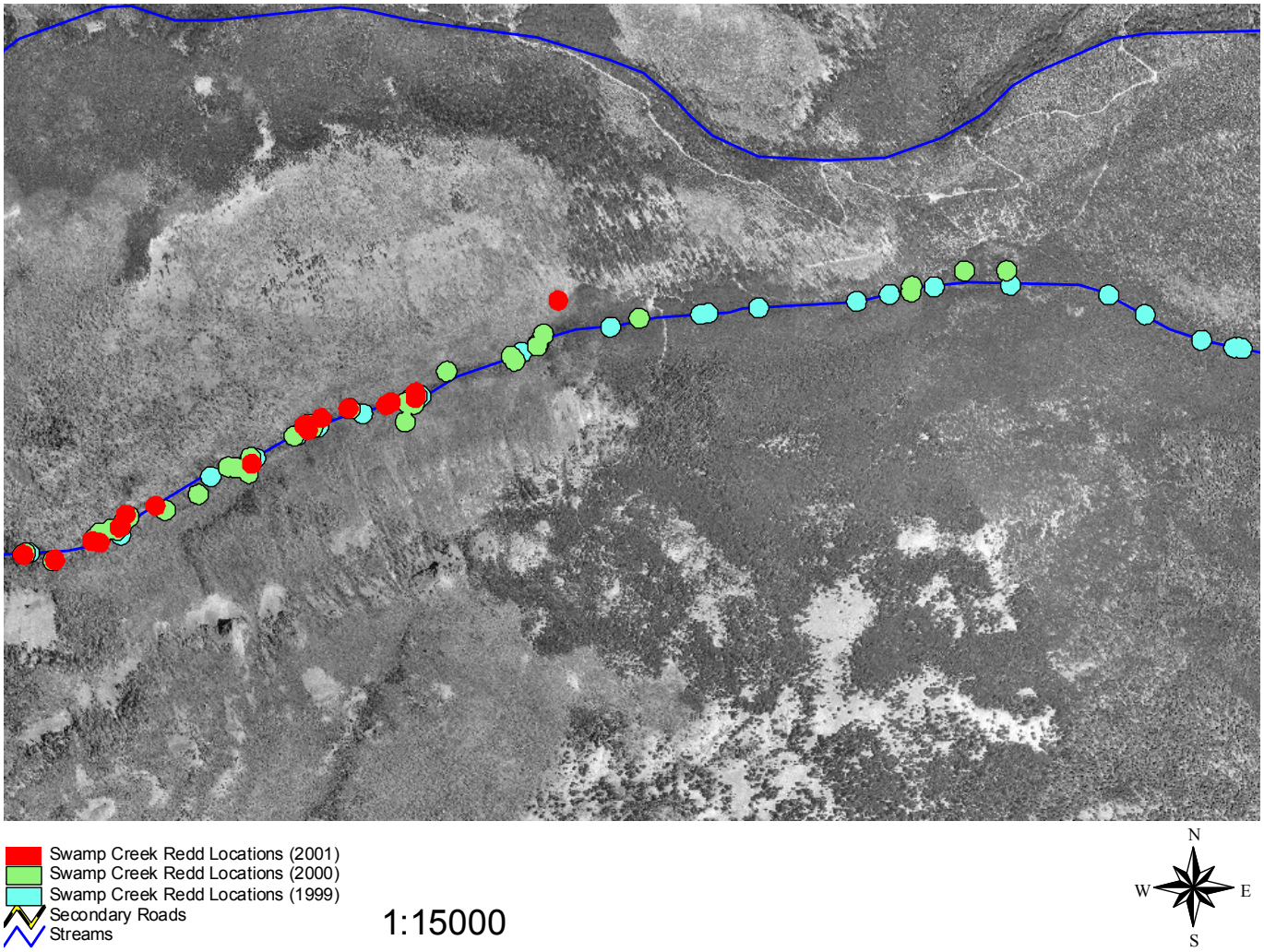
Appendix D-3. Comparison of redd locations from 1999 to 2001 in upper North Fork, Horseshoe, and Deadhorse creeks.



Appendix D-4. Comparison of redd locations from 1999 to 2001 in Sheep Creek.



Appendix D-5. Comparison of redd locations from 1999 to 2001 in Swamp Creek.



# Use of radio telemetry to document movements of bull trout in the Upper Malheur River, Oregon.

AUTHOR: JASON FENTON AND LAWRENCE SCHWABE, BURNS PAIUTE TRIBE FISH AND WILDLIFE DEPARTMENT

In 2001, research was conducted on bull trout *Salvelinus confluentus* in the Malheur River above Warm Springs Reservoir (referred to as the Upper Malheur River). Bull trout in the Upper Malheur River are at a high risk of extinction and are suppressed by habitat degradation, downstream losses, and hybridization and competition with brook trout *Salvelinus fontinalis* (Ratliff and Howell 1992; Buchanan et al., 1997).

Past fish and creel surveys were used to estimate the current distribution of bull trout, however, little is known on the seasonal distribution of bull trout in the Upper Malheur River. In 2000, radio tags were implanted into 20 bull trout from the Upper Malheur River (Schwabe 2000). Considering both the biological and political sensitivities surrounding the management of bull trout habitat, a clear understanding of their life history pattern is necessary to guide land management decisions and activities.

The Malheur River Bull Trout Workgroup developed the following objectives for bull trout:

1) Document the migratory patterns of adult and subadult bull trout in the Upper Malheur River.
2) Determine the seasonal use of Warm Springs Reservoir by bull trout.
3) Determine the timing of bull trout spawning in the Upper Malheur River.

The focus of the study area for the 2001 field season was primarily on the Upper Malheur River from Warm Springs Reservoir upstream to the headwaters (Figure 1). This report will reflect the research completed from 16 May 2001 to 2 April 2002.

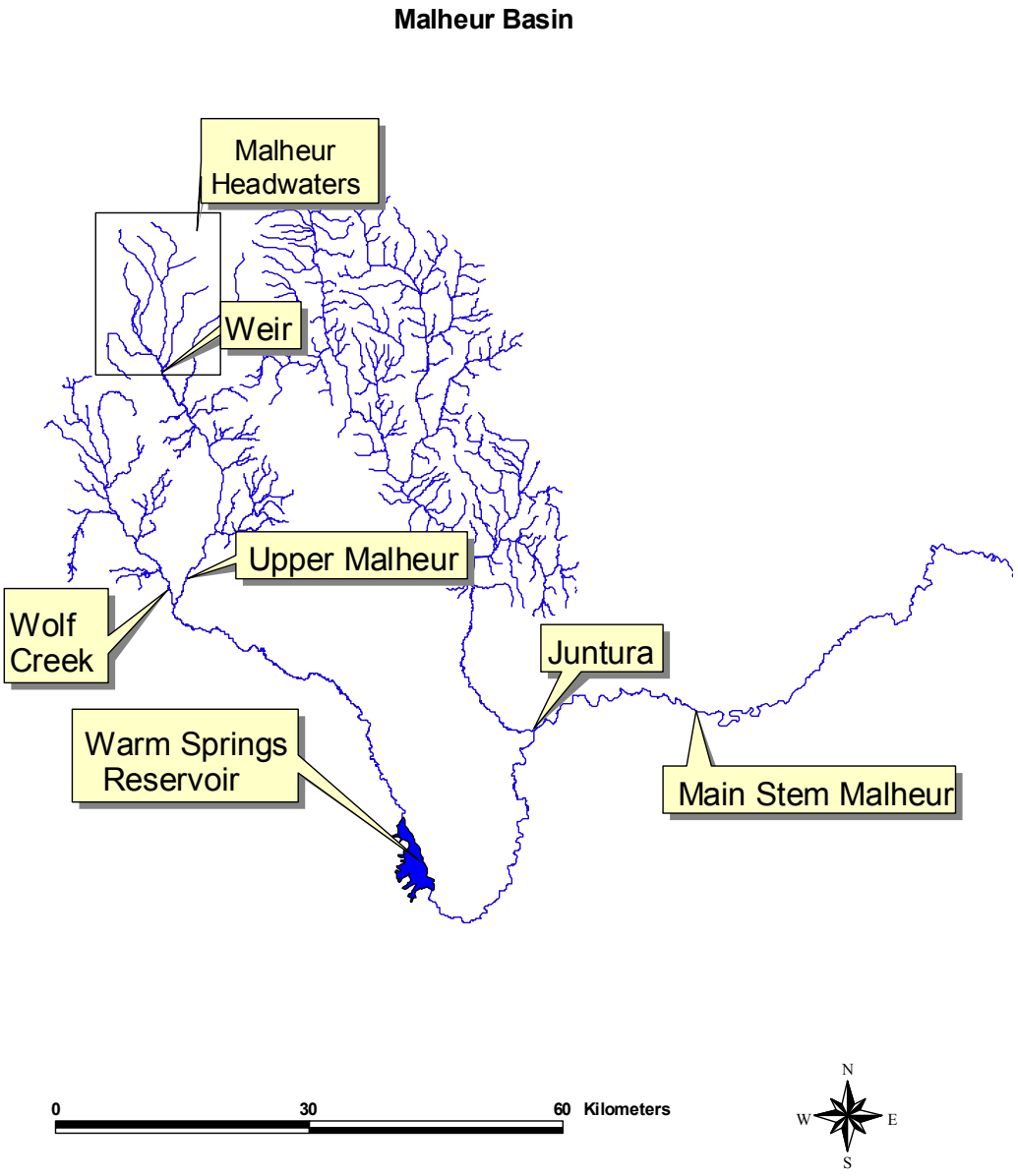



Figure 1. Study area for bull trout migration study in 2001.

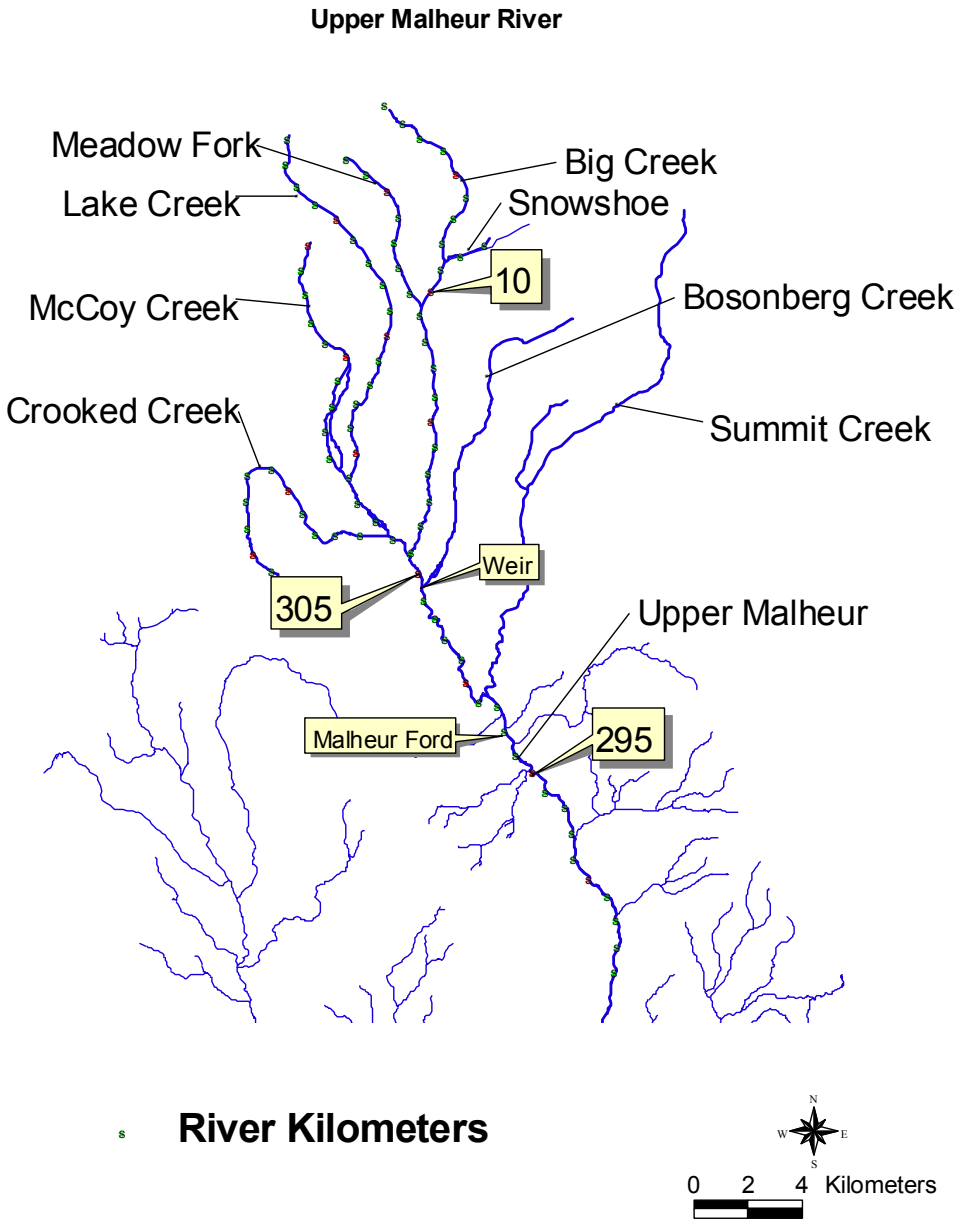



Figure 2. Study area for bull trout migration study in 2001.

# Methods

## Fish Collection

Bull trout were collected by trapping using a weir. The weir trap was set on the Upper Malheur River at river kilometer (RK) 304 approximately 120 meters below the confluence of Bosonberg Creek. (Figure 2) The weir trap was designed to span a width slightly larger than the wetted channel and was installed on a slight angle across the channel. The structure was constructed of 12-foot aluminum panels consisting of ½ inch diameter holes. Conduit rods were spread ¼ inch apart. The weir was stabilized with fence posts that were anchored into the streambed. Weir panels were attached to the fence post with fencing wire. Upstream and downstream trap boxes were placed near opposite stream banks and interlocked into the weir panels. All fish caught in the upstream trap were released in calm water upstream from the weir site. Those caught in the downstream trap were released below the site. The Malheur River Bull Trout Workgroup were concerned with detaining bull trout in traps for extended periods of time. Therefore, the weir trap was checked twice a day in May through June when bull trout catches were relatively high and once a day from July to October.

## Radio and Passive Intergraded Transponder (PIT) Tag Implantation

Radio transmitters manufactured by Advanced Telemetry Systems Inc. (ATS) had external whip antennas that emitted a unique frequency in either the 150 or 151 MHz band. Radios came in three sizes and are guaranteed by the manufacturer for up to 90 days (8g radios), 175 days (11g radios) and 208 days (17g radios), respectively. Transmitter weight was not to exceed 3% of the bull trout body weight: 8g radio (for bull trout > 266g), 11g radio (for bull trout > 366g), and 17g radio (for bull trout > 560g). Bull trout weighing less than 266g were not implanted with radios.

When using PIT tags, the ODFW district biologist requested that fish have a minimum fork length of 150 millimeters. PIT tag injectors and 1 ¼ inch X 12 gauge injector needles purchased from BioMark Inc. were used to insert PIT tags into the subcutaneous area of the dorsal fin.

The Malheur Bull Trout Working Group set the maximum target of 20 bull trout to be collected and radio tagged in the Upper Malheur River at the weir trap site (RK 304). Radio tagged bull trout were released at the site of capture.

Captured bull trout were anesthetized with MS 222 (tricaine methanesulfonate), measured (fork length in mm), and weighed (g). Radio transmitters were inserted internally through a midline internal incision (Ross and Kleiner 1982). The external whip antennas were threaded through the body cavity and exited behind the pelvic fin, during which time the gills were bathed with diluted MS 222 (60 mg/liter) using a suction apparatus (turkey baster). Absorbable surgical sutures or surgical staples and super glue were used to seal the incision. After surgery, fish were held in fresh water until equilibrium was achieved, then released back into the river. Fish tank

aerators were used in all holding buckets to provide increased oxygen levels during recovery and when anesthetizing fish.

### Radio Telemetry

The tracking of radio tagged bull trout was conducted on an average of four times a week to obtain frequent locations of each fish. An ATS receiver, Yagi antenna, and a 12 channel hand-held GPS unit were used to locate fish. Foot travel and a vehicle were the primary means to track individual fish. Visual identification for the fish was preferred but rarely possible. The frequency of each fish, time located, and Universal Transverse Mercator (UTM) location were recorded for all positive identifications. Aerial surveys were conducted from a fixed winged aircraft when observations of tagged fish were less than expected. Bull trout were also located by angling or by capture in the weir trap. If applicable, additional information was taken on fish locations including stream temperatures, habitat characteristics, redds or pairing fish, and cover present.

## Results

### Fish Collection

The weir trap was set on 16 May 2001 on the Upper Malheur River at RK 304 located just downstream from the mouth of Bosonberg Creek. The trap was dismantled on 26 October 2001. Between 17 May 2001 and 26 October 2001 the weir trap collected 82 bull trout including 16 recaptures from the current year and 8 recaptures from the 2000 collection effort. The fork length of bull trout ranged from 139mm to 566mm, with a mean length of 283 mm. Fish weight ranged from 23 to 1668 grams, with a mean of 322 grams.

The upstream trap box collected 68 bull trout while the downstream trap box collected 14 bull trout, including recaptures from both the current sampling year and previous year. Five of the eight bull trout recaptured from 2000 received a new radio tag implant in 2001 (Table 15).

Twenty bull trout captured in the weir were implanted with radio tags (Table 14). The target of 20 implanted fish with radios was achieved by 19 June 2001. A total of 77 bull trout were caught the first eleven weeks of operation, or approximately 94% of the total catch, while the last eleven weeks of trap operation collected only five bull trout, or approximately 6% of the total catch (Figure 3). Bull trout collection in the downstream trap box and the upstream trap box from 24 May to 26 July 2001was 10 and 67 bull trout respectively. Bull trout collection in the downstream trap box and the upstream trap box from 15 August to 26 October 2001 was four and one bull trout respectively.

Other species caught in the weir trap on the Upper Malheur include: brook trout *Salvelinus fontinalis*, rainbow trout *Oncorhynchus mykiss*, mountain whitefish *Prosopium williamsoni*, bridgelip suckers *Catostomus columbianus*, speckled dace *Rhinichthys osculus*, longnose dace *Rhinichthys cataractae*, sculpin *Cottus spp*., and redside shiners *Richardsonius balteatus*. (See Appendix E for weekly catches.)

Table 14. Bull trout captured in weir that were implanted with a radio tag 2001. Upper Malheur River.

| Date Of Implant | Radio Frequency | Weight (g) | Fork Length (mm) | Maximum Distance Traveled Above Weir Trap (km) |
|---|---|---|---|---|
| 5-25-01 | 151.854* | 1005 | 443 | 11 |
| 5-25-01 | 151.683 | 1294 | 493 | 10 |
| 5-25-01 | 151.134* | 507 | 371 | 3 |
| 5-27-01 | 151.884 | 440 | 341 | 12 |
| 5-27-01 | 150.804* | 370 | 344 | 11 |
| 5-27-01 | 151.593 | 1668 | 566 | 10 |
| 5-27-01 | 151.893 | 435 | 341 | 12 |
| 5-28-01 | 151.875 | 1425 | 531 | 11 |
| 5-28-01 | 151.864* | 831 | 431 | 8 |
| 5-28-01 | 151.192 | 392 | 338 | 12 |
| 5-28-01 | 151.045 | 455 | 350 | 12 |
| 6-03-01 | 151.363 | 404 | 325 | 4 |
| 6-03-01 | 151.695* | 605 | 390 | 5 |
| 6-05-01 | 151.173 | 487 | 353 | 12 |
| 6-08-01 | 151.206 | 374 | 317 | 5 |
| 6-10-01 | 151.224 | 381 | 311 | 7 |
| 6-17-01 | 151.014 | 352 | 317 | 12 |
| 6-18-01 | 150.685 | 262 | 297 | -3 |
| 6-19-01 | 150.863 | 334 | 311 | 1 |
| 6-19-01 | 151.755 | 980 | 445 | 6 |

* Recaptured from previous year (2000).

Table 15. Bull trout that were retagged in 2001. Upper Malheur River.

| Date of Implant in 2000 | Date of re-Implant in 2001 | Radio Frequency in 2000 | Radio Frequency in 2001 | Maximum Distance Traveled Above Weir in 2000 (km) | Maximum Distance Traveled Above Weir in 2001 (km) |
|---|---|---|---|---|---|
| 6-05-00 | 5-25-01 | 151.223 | 151.854 | 13 | 11 |
| 6-21-00 | 5-25-01 | 151.869 | 151.134 | 12 | 3 |
| 6-26-00 | 5-27-01 | 151.195 | 150.804 | 13 | 11 |
| 6-19-00 | 5-28-01 | 151.851 | 151.864 | 14 | 8 |
| 6-21-00 | 6-03-01 | 151.703 | 151.695 | 13 | 5 |

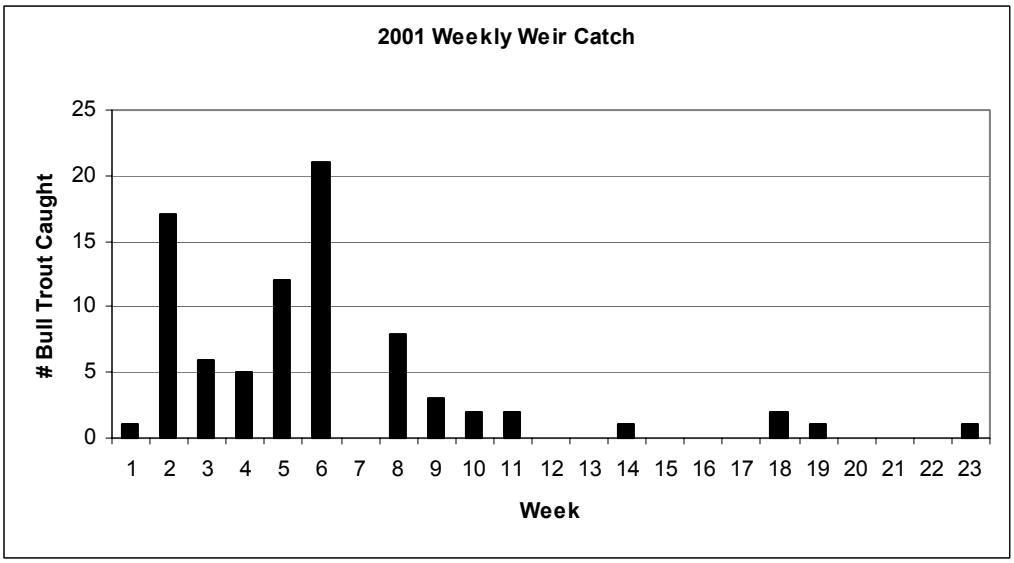



Figure 3. Weekly catch of bull trout in weir. Upper Malheur River.

## Telemetry Results

A total of 408 observations were documented between 29 May 2001 and 2 April 2002 (Table 16). Most of the radio tracking was conducted by foot and vehicle. The Tribe and the US Forest Service conducted three aerial tracking flights by fixed wing aircraft for radio tagged bull trout. The first flight was on 9 January 2002, the second flight was on 14 February 2002, and the third flight was on 2 April 2002.

Table 16. Number of bull trout tracking observations during 2001. Upper Malheur River.

| Foot Observations | Vehicle Observations | Plane Observations | **Total Observations** |
|---|---|---|---|
| 257 | 121 | 30 | **408** |

Bull trout were observed in the Upper Malheur River, Big Creek, Meadow Fork of Big Creek, Snowshoe Creek, and in the lower part of Lake Creek. Radio tagged bull trout were also found below the weir trap, though none were released downstream of the trap after surgery. No bull trout were documented to use Warm Springs Reservoir during the study. Monthly observations of radio tagged bull trout can be viewed in Appendix B.

# Discussion

## Fish Collection

Data from the weir trap suggests that bull trout were migrating upstream from the Upper Malheur River from below RK 304 starting in late May 2001 through mid July 2001. Between week 12 and 17, only one bull trout was captured in the downstream trap. This bull trout was a radio tagged fish and had visible wounds. Subsequently, the bull trout was found dead five days later. Between week 22 and the middle of week 23, the weir trap was opened and the traps shut due to the theory of the bull trout becoming weir shy. The radio tagged bull trout were congregating upstream of the trap. After the trap was opened most of the bull trout moved downstream. The trap was again functional for four more days until it was taken out due to ice buildup. Appendix E shows the weekly count of bull trout captured in the weir.

## Telemetry

Preliminary results from the second year of study in the Upper Malheur River suggest bull trout are migrating upstream from below RK 304 in May through August. Tracking observations from June to early September 2001 document fish migrating upstream. In addition, radio tagged fish tend to migrate into Big Creek with limited migration into Lake Creek drainage. The data suggests that migratory bull trout in this system are limited to the Big Creek drainage although in previous studies bull trout have been documented in the upper reaches of Lake Creek (Bowers et al. 1993). Two bull trout entered Lake Creek but did not move upstream of RK 3. The first bull trout entered Lake Creek in the third week but the signal was lost and the fish was never located again. The second bull trout entered Lake Creek the fifth week but returned back to the Upper Malheur River and continued up to Big Creek.

The most upstream observation for each individual bull trout occurred from 21 July to 21 September 2001. The radio tagged bull trout that entered the Big Creek drainage were in the spawning habitat as early as July and leaving in September and October.

Tracking observations from early September 2001 to early October 2001 show fish migrating downstream. On the 2nd of April 2002 the lowest fish was documented to be 31 km below the weir site at the mouth of Wolf Creek (RK 287).

Table 17. Radio tagged bull trout that were lost. Upper Malheur River, 2001.

| Radio Frequency | Date Radio Recovered | Date Radio Implanted | Days Active | Maximum Distance Traveled Above Weir (km) | Where Radio Was Recovered |
|---|---|---|---|---|---|
| 151.363 | 6/5/01 | 6/3/01 | 2 | 4 | Signal lost in lower Lake Creek |
| 150.863 | 6/28/01 | 6/19/01 | 9 | 1 | Near osprey nest 1km below weir |
| 151.695 | 7/3/01 | 6/3/01 | 30 | 5 | In Big Creek with fish near Big Creek Campground |
| 150.685 | 7/11/01 | 6/18/01 | 24 | -3 | Near same osprey nest as 150.863 |
| 151.224 | 8/2/01 | 6/10/01 | 54 | 7 | In Big Creek 7 km above weir |
| 151.864 | 8/10/01 | 5/28/01 | 75 | 8 | In Big Creek 8 km above weir |
| 151.206 | 8/22/01 | 6/8/01 | 74 | 5 | Upper Malheur River with fish 2.5 km below weir |
| 150.804 | 9/2/01 | 5/27/01 | 99 | 11 | Near osprey nest by Meadow Fork of Big Creek |
| 151.875 | 9/21/01 | 5/28/01 | 117 | 11 | In Meadow Fork of Big Creek |
| 151.014 | 10/12/01 | 6/17/01 | 118 | 12 | On land 200 meters from water, .5 km below weir |

Out of the twenty fish that were radio tagged, nine radios were recovered and one radio signal was lost (Table 17). One fish was tracked 2 km into Lake Creek but for unknown reasons was never located again.

Radio tags found prior 15 August 2001, are considered to be pre-spawn mortalities. Therefore, five fish are considered to be pre- spawn mortalities. Two radio tags were located near the same osprey nest near Meadowfork Creek. One radio tag was found with the fish in Big Creek on 3 July 2001. Two radio tags were recovered without the bull trout in Big Creek above Big Creek Campground.

Radios found after 15 August 2001, are considered to be post-spawn mortalities. Therefore, four fish are considered to be post-spawn mortalities. One radio tag was located near an osprey nest near Meadowfork Creek. One radio tag was found in Meadowfork Creek on 21 September 2001. One radio tag was recovered with the fish 2.5 kilometers below the weir on 22 August 2001. The last radio tag was recovered on 12 October 2001, 0.5 kilometers below the weir.

No bull trout were documented in Warm Springs Reservoir. In 2000, bull trout were documented to migrate only 8 kilometers below the weir. In 2001, we documented a bull trout 31 kilometers downstream of the weir trap site and was located at the mouth of Wolf Creek. This was the last site that was documented before we assumed the radio stopped functioning. The bull trout located at the mouth of Wolf Creek was still 64 kilometers upstream of Warm Springs Reservoir.

The two-year telemetry research on adult bull trout in the Upper Malheur River suggest these fish over winter in the canyon reaches of the Upper Malheur River (RM 170 to 187). Upstream migration to the headwaters begins in the spring, presumably caused by an increase in stream discharge and water temperatures. Migratory bull trout reach the critical spawning areas of upper Big Creek, Meadow

Fork, and Snowshoe Creek in July and August. By the beginning of September, migratory bull trout are migrating downstream. Downstream migration may slow in December to March, but the data collected suggest downstream migration still occurs during the winter months.

During the two-year radio telemetry study, minimal bull trout were utilizing the lower reach of Lake Creek and no radio tagged bull trout migrated onto the spawning areas (RM 6 to 10). Bull trout occur in small numbers in Lake Creek and it is undetermined if these fish are resident or a small migratory population. The small population or lack of migratory bull trout utilizing Lake Creek may be the result of poor habitat conditions, stronghold population of brook trout, and/or Lake Creek stream temperatures that may act as a thermal barrier deterring migration into the drainage.

Future research objectives for the Upper Malheur River bull trout population should include: 1) determine the distribution of sympatric and allopatric populations of bull trout; 2) determine the rate of hybridization and introgression between brook and bull trout populations; 3) determine the distribution of subadult bull trout in the Upper Malheur River subbasin; and 4) initiate, develop and implement a brook trout eradication project.

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Bowers, W., P. Dupee, M. Hanson, and R. Perkins. 1993. Bull trout population summary Malheur River Basin. Unpublished Data. Oregon Department of Fish and Wildlife. Hines, OR.

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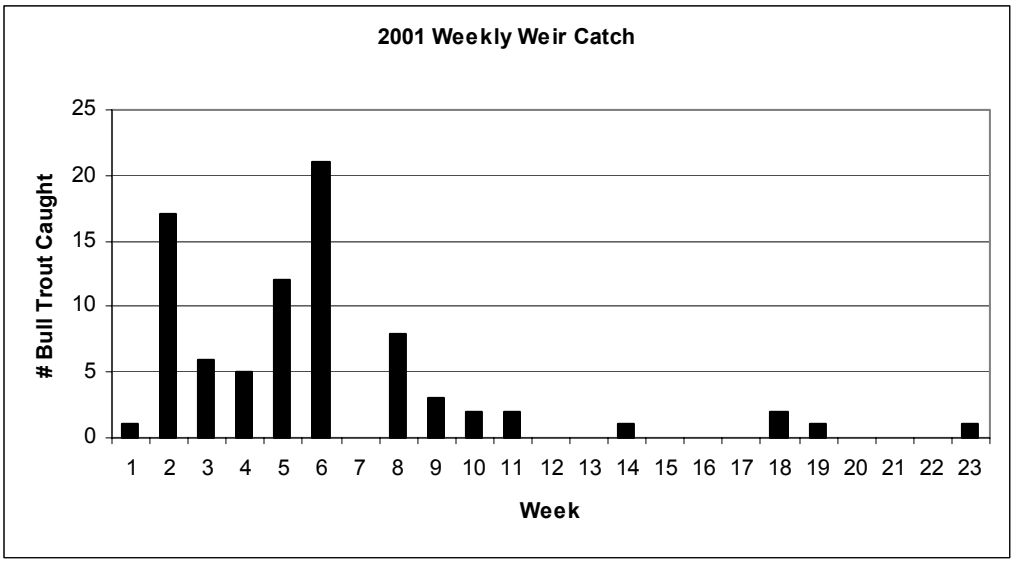
Ross, M.J. and C.F.Kleiner. 1982. Sheilded – needle techniques for surgically implanting radio – frequency transmitters in fish. Progressive Fish – Culturist 44 (1): 41 –43.

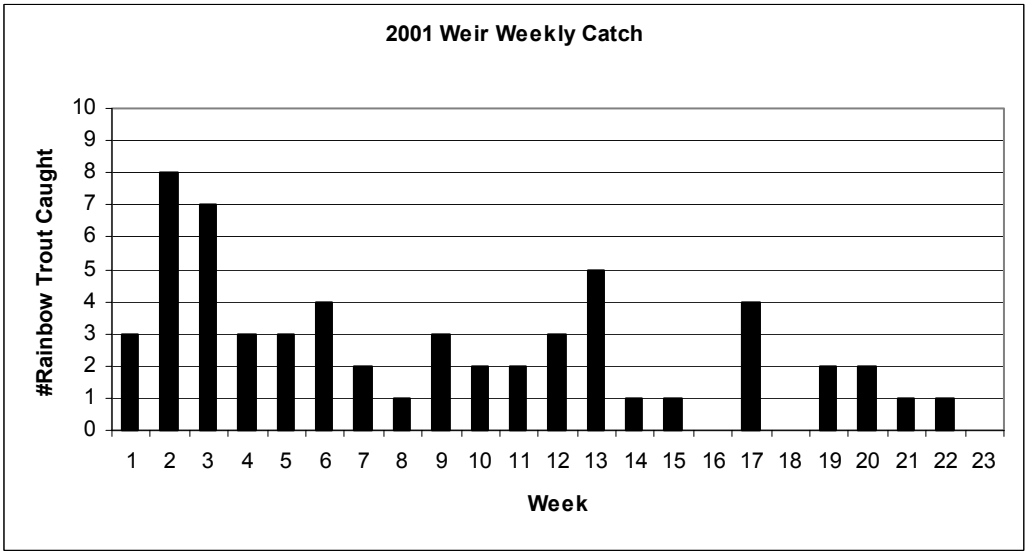
Schwabe, L. 2000. Evaluate the life history of native salmonids within the Malheur Subbasin. Bonneville Power Administration (BPA) project # 9701900 / 9701901.

## Appendix E. Weekly Catches of Fish in Weir in the Upper Malheur River, 2001.

Appendix Figure E-1. Weekly Catches of Fish in Weir in the Upper Malheur River, 2001.

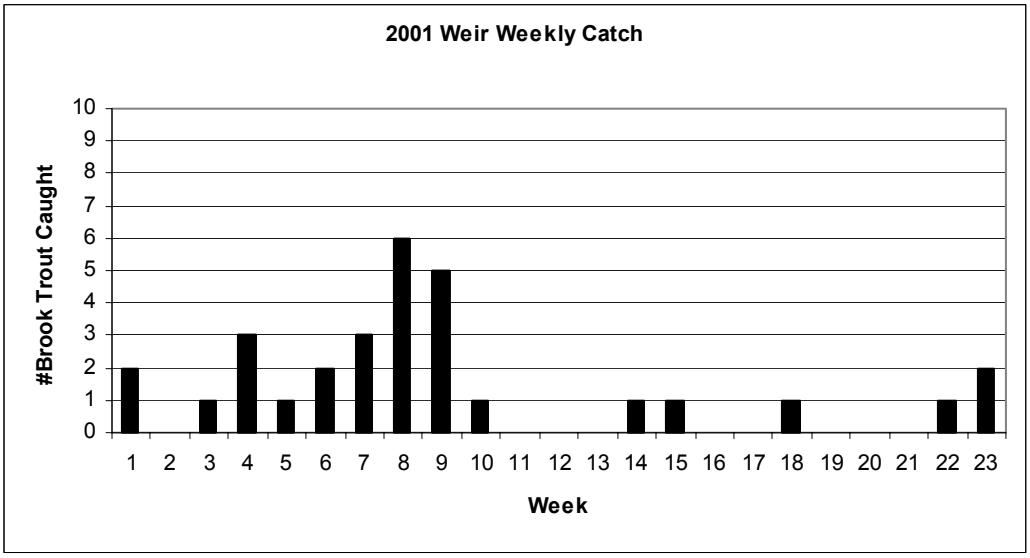
May 16 to October 26

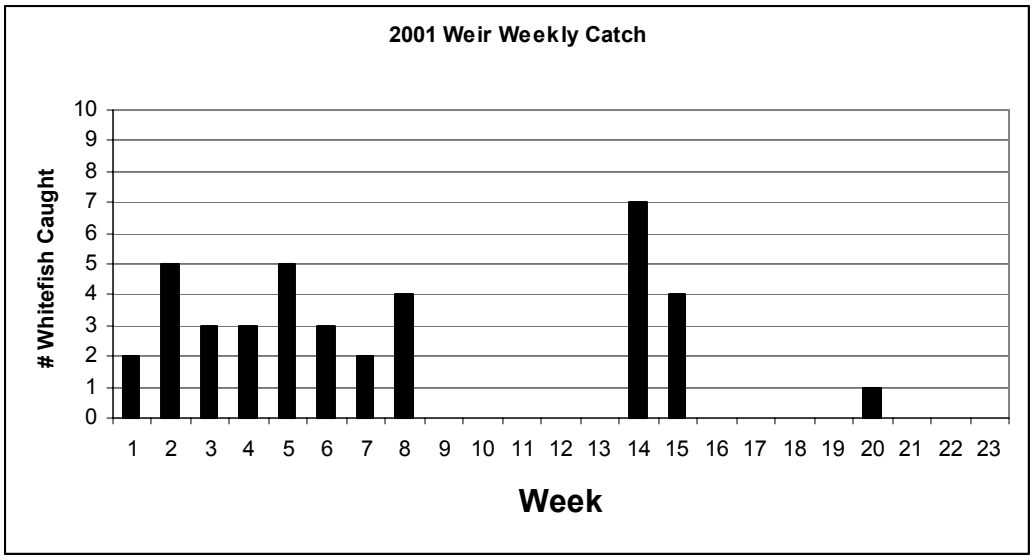


Appendix Figure E-2. Weekly Catches of Fish in Weir in the Upper Malheur River, 2001.

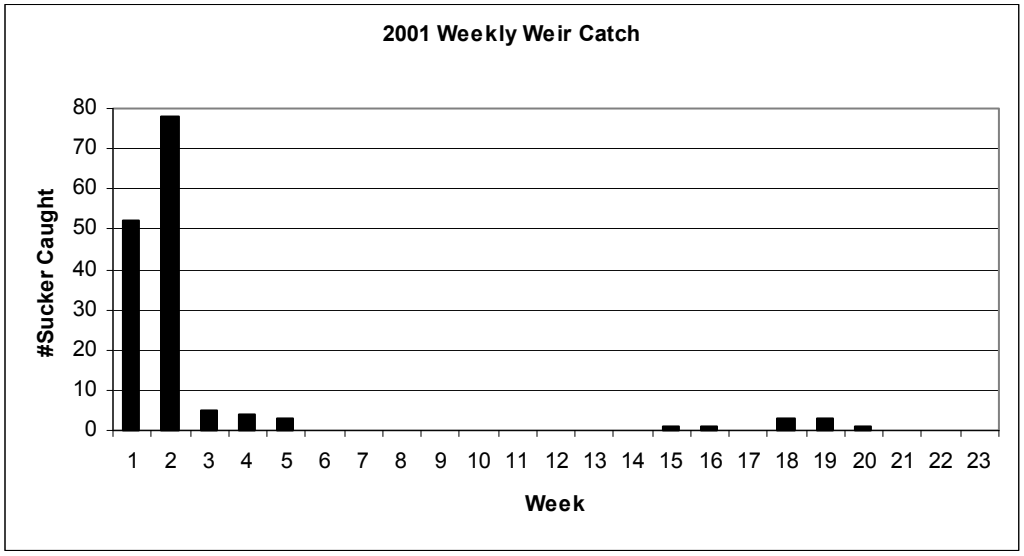
May 16 to October 26

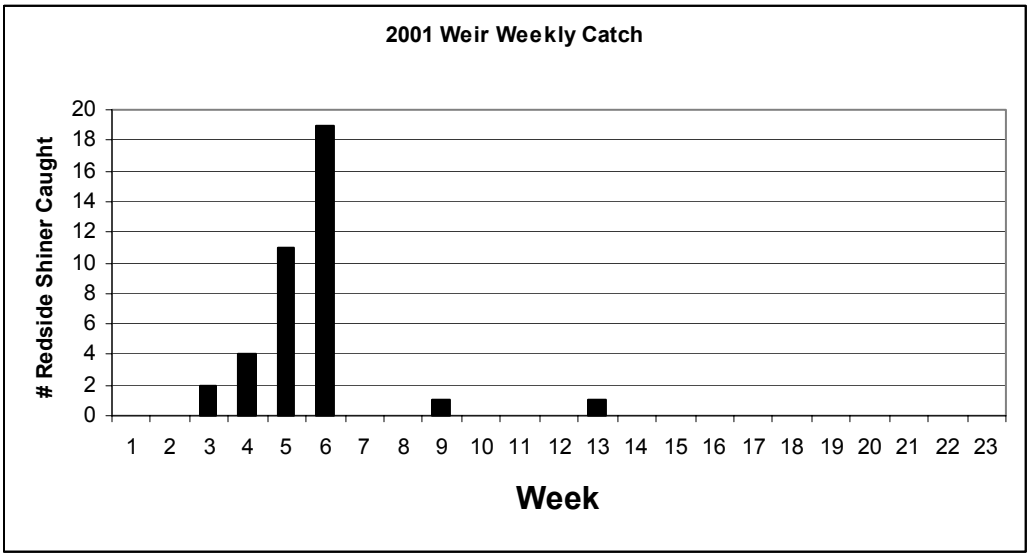


Appendix Figure E-3. Weekly Catches of Fish in Weir in the Upper Malheur River, 2001.

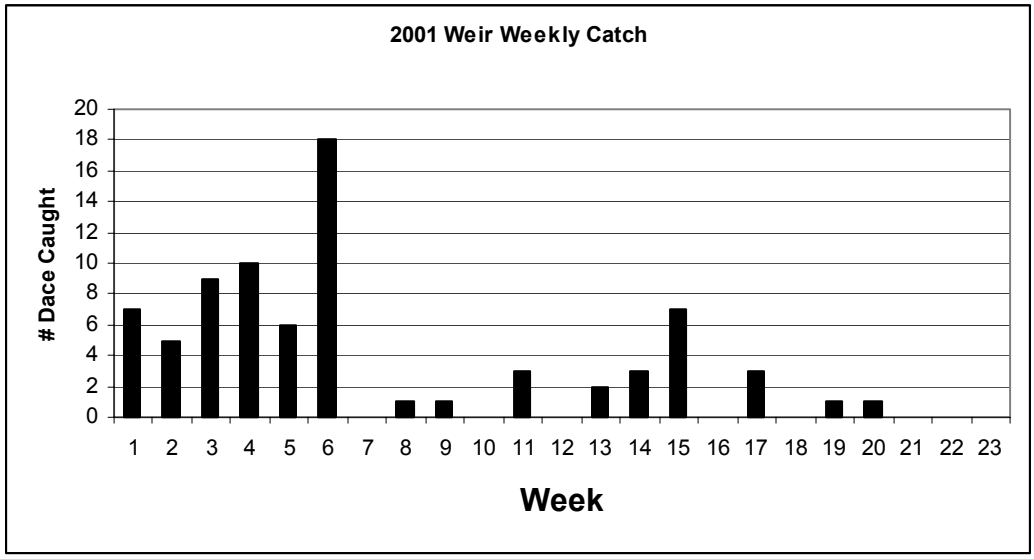
May 16 to October 26

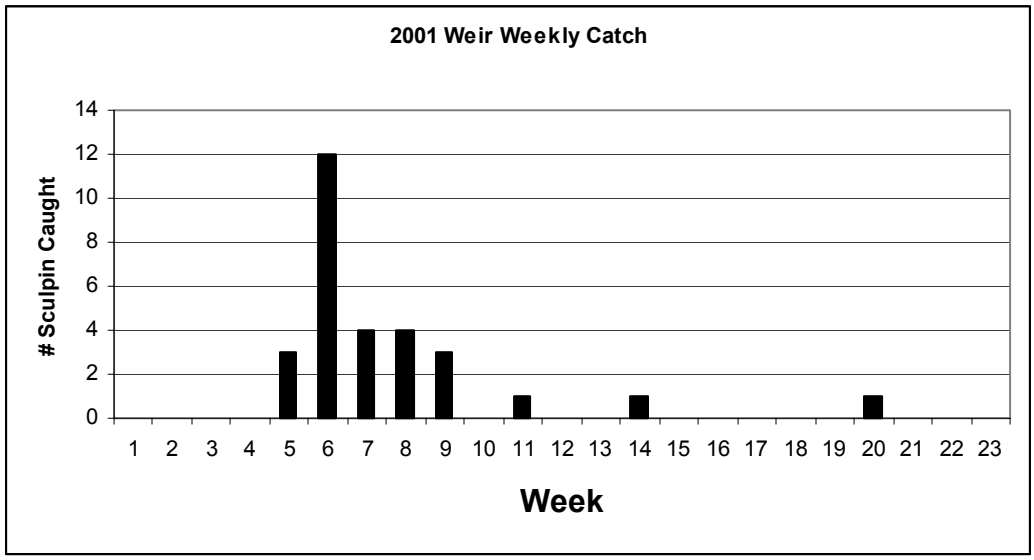


Appendix Figure E-4. Weekly Catches of Fish in Weir in the Upper Malheur River, 2001.

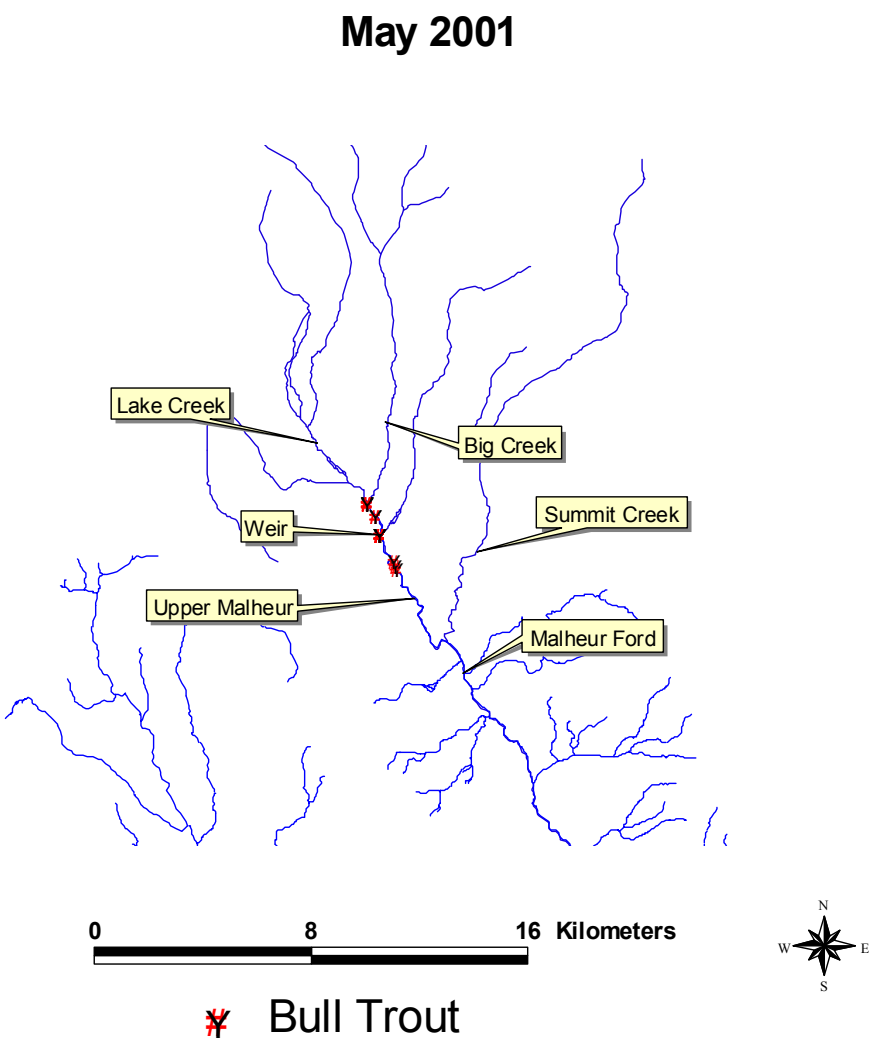
May 16 to October 26



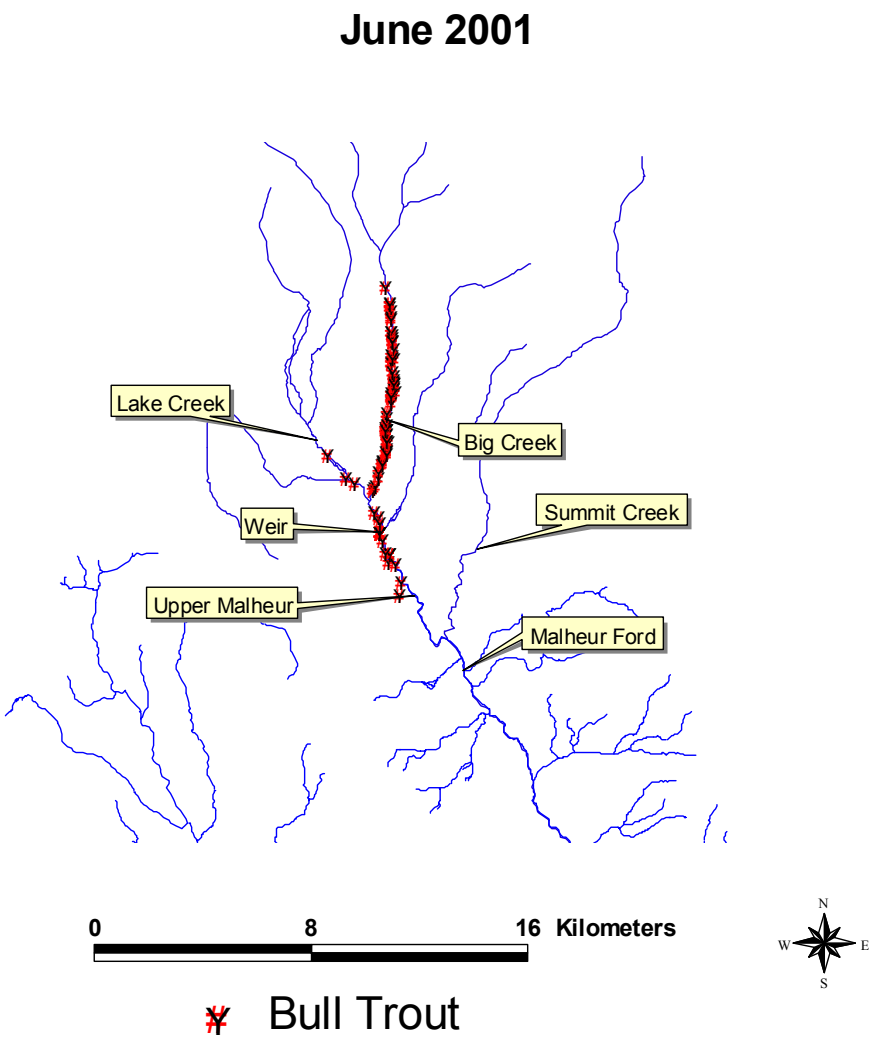



## Appendix F. Monthly Observations of Radio Tagged Bull Trout in the Upper Malheur River, 2001.

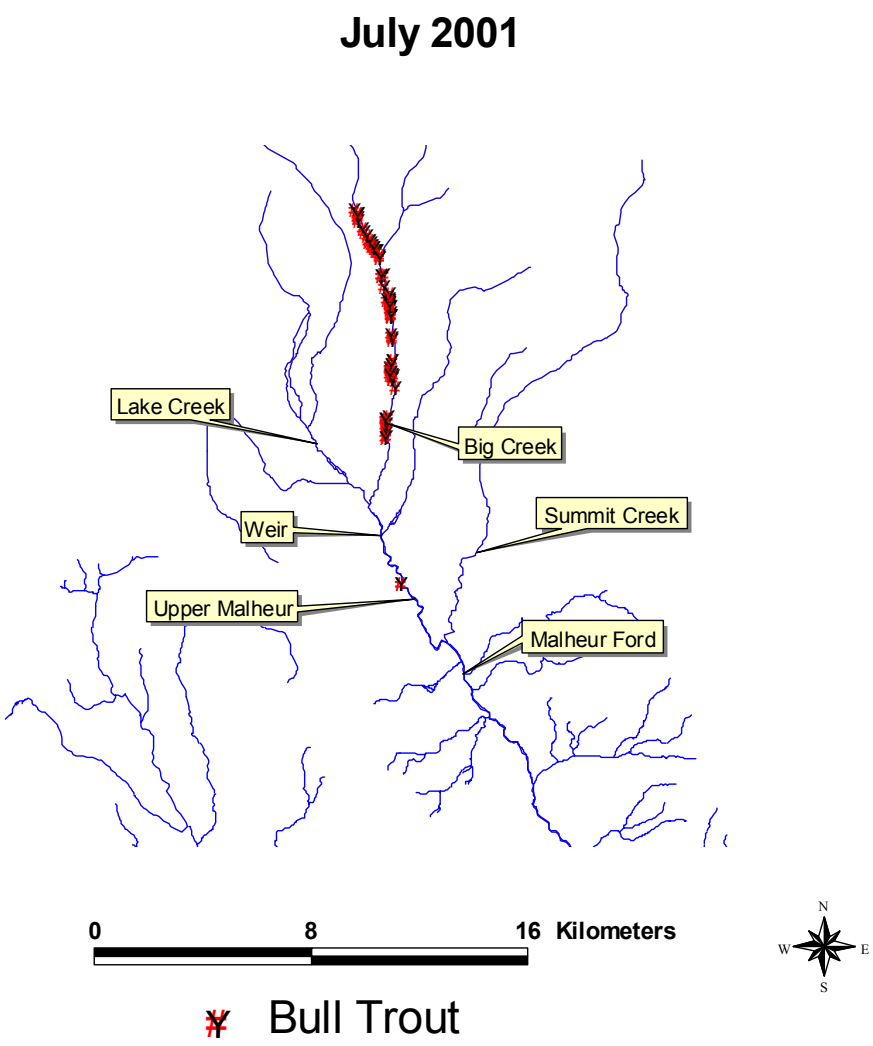
Appendix F-1. Monthly Observations of Radio Tagged Bull Trout in the Upper Malheur River, 2001.



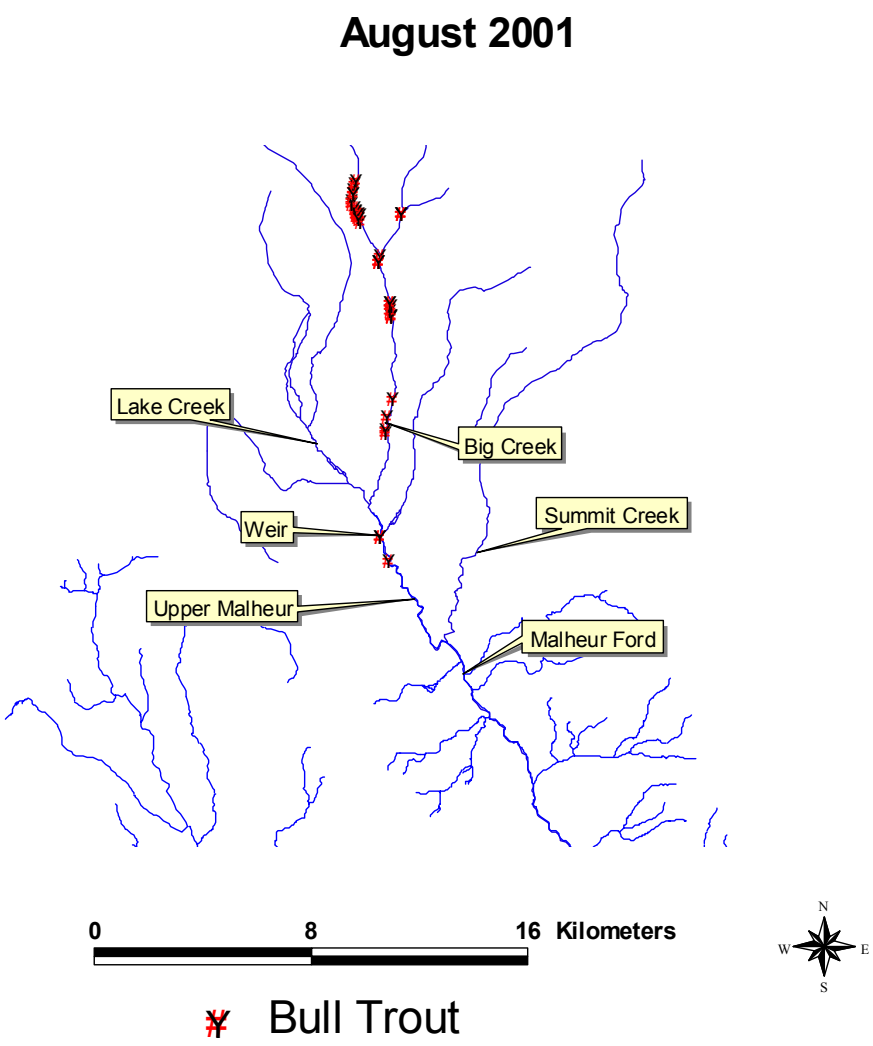
Appendix F-2. Monthly Observations of Radio Tagged Bull Trout in the Upper Malheur River, 2001.



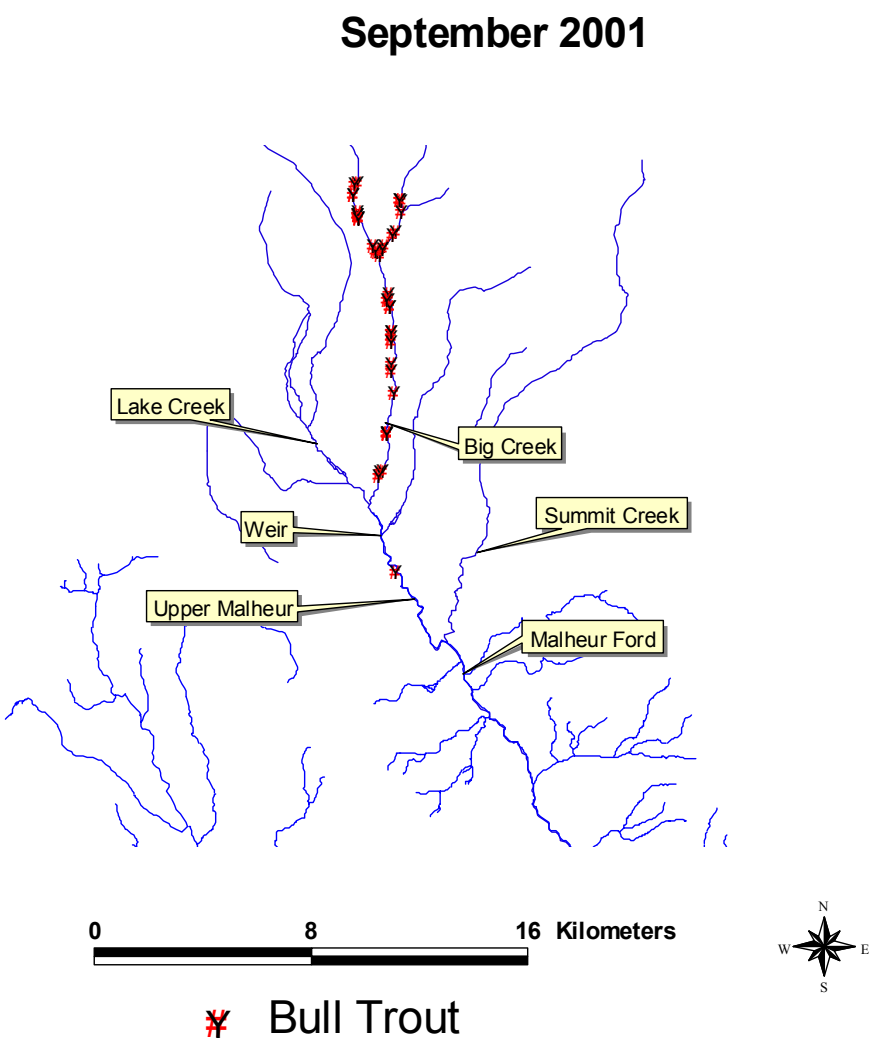
Appendix F-3. Monthly Observations of Radio Tagged Bull Trout in the Upper Malheur River, 2001.



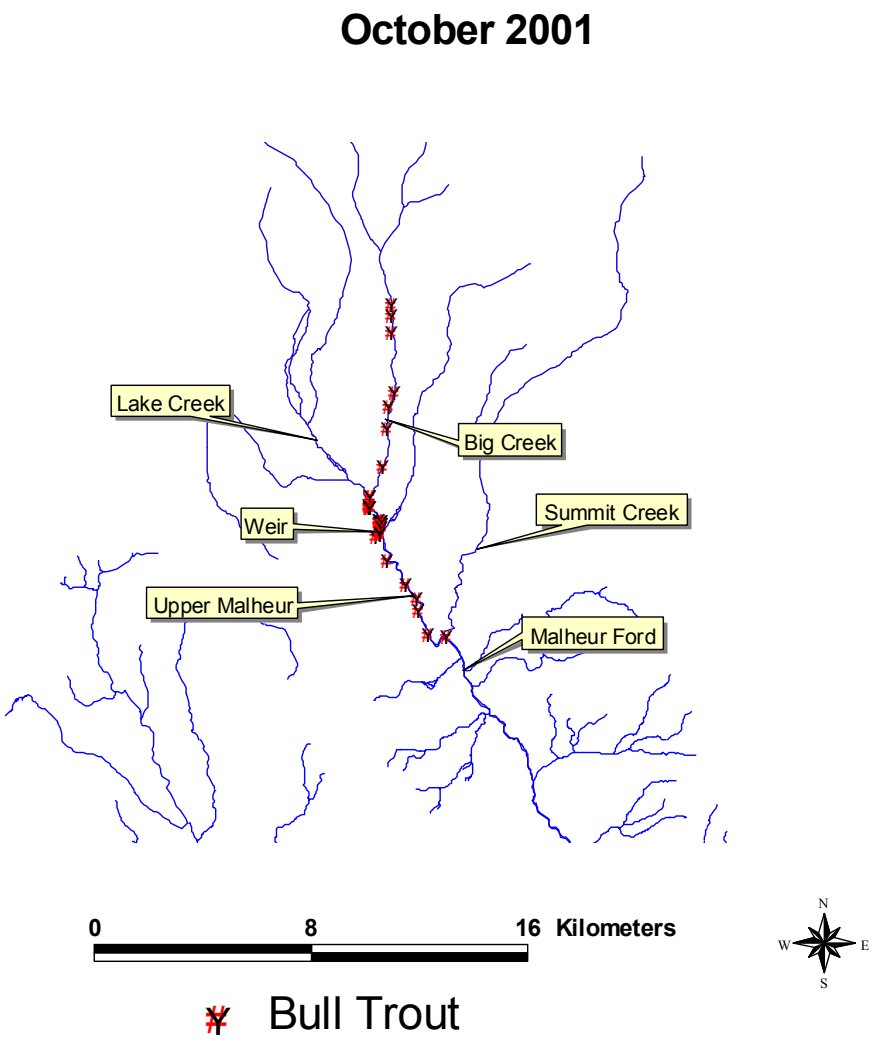
Appendix F-4. Monthly Observations of Radio Tagged Bull Trout in the Upper Malheur River, 2001.



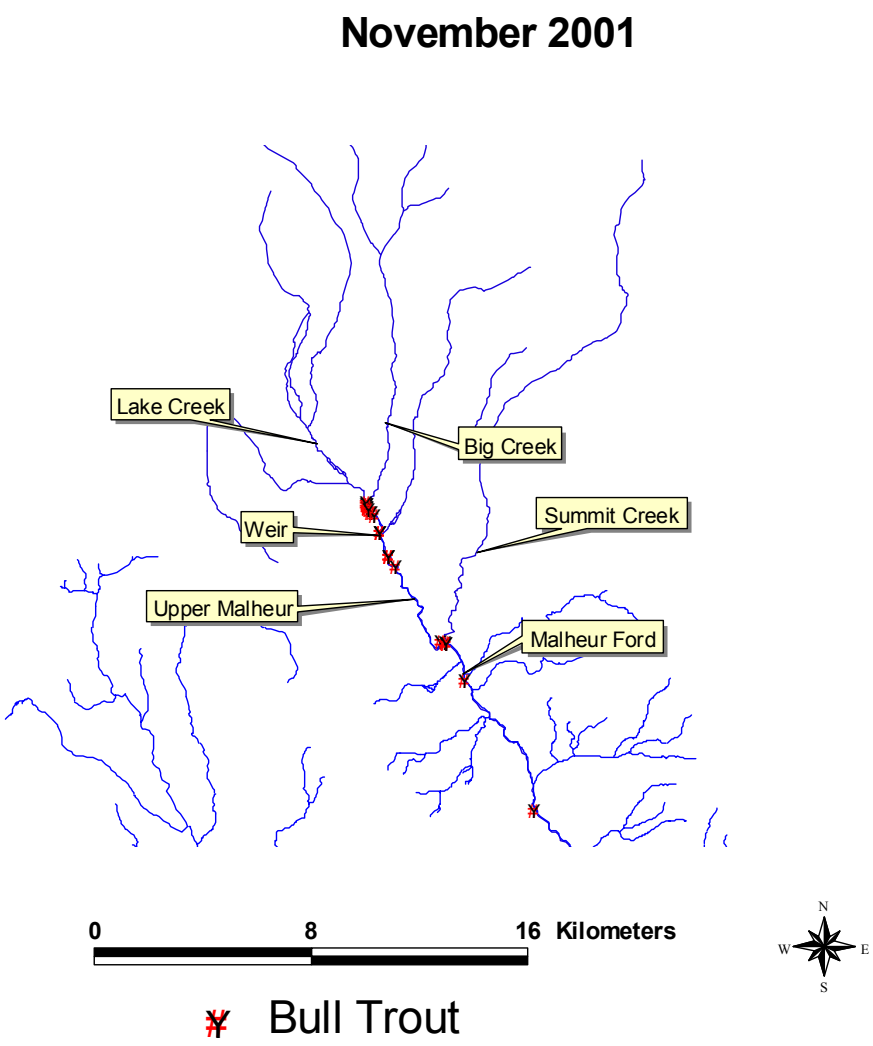
Appendix F-5. Monthly Observations of Radio Tagged Bull Trout in the Upper Malheur River, 2001.



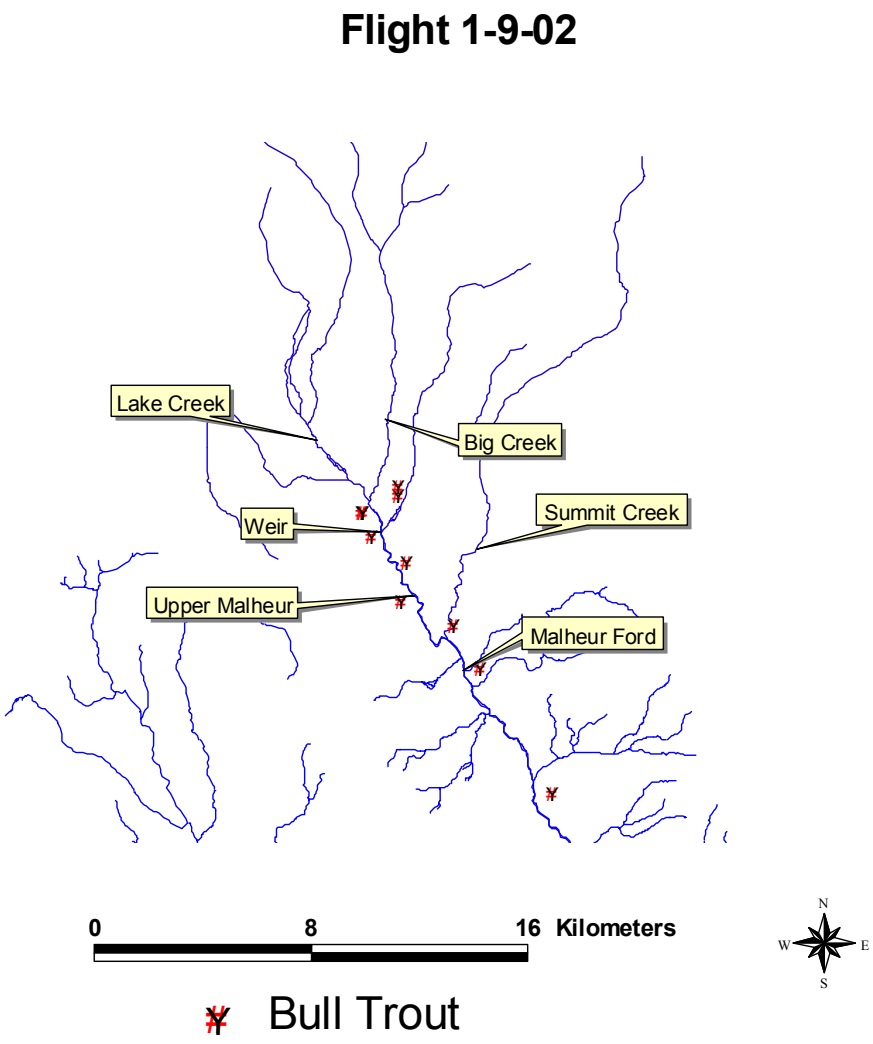
Appendix F-6. Monthly Observations of Radio Tagged Bull Trout in the Upper Malheur River, 2001.



Appendix F-7. Monthly Observations of Radio Tagged Bull Trout in the Upper Malheur River, 2001.

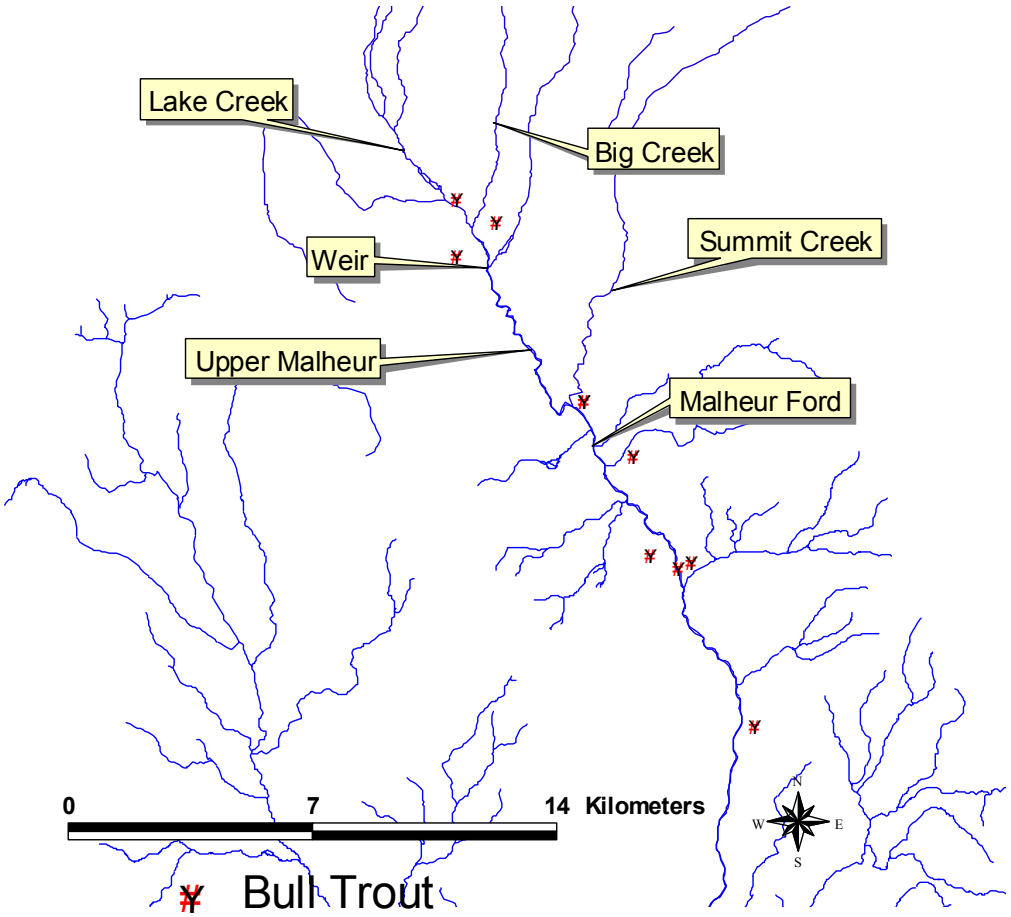


Appendix F-8. Monthly Observations of Radio Tagged Bull Trout in the Upper Malheur River 2002.



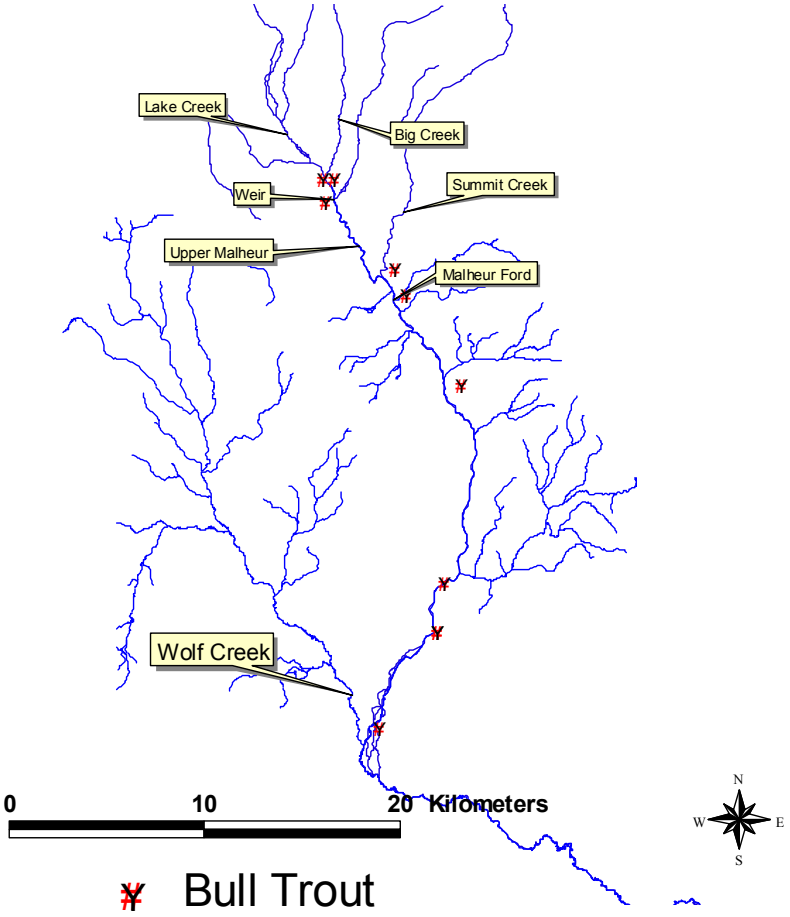
Appendix F-9. Monthly Observations of Radio Tagged Bull Trout in the Upper Malheur River 2002.

## Flight 2-14-02



Appendix F-10. Monthly Observations of Radio Tagged Bull Trout in the Upper Malheur River 2002.

## Flight 4-2-02



## Appendix G. Daily and Seasonal Catch of Bull Trout at Weir Site (RK 306) in Upper Malheur River, 2001.

| DATE | TEMPERATURE °C | UPSTREAM COUNT DAILY | UPSTREAM TOTAL | DOWNSTREAM COUNT DAILY | DOWNSTREAM TOTAL |
|---|---|---|---|---|---|
| 5/17/01 | N/A | 0 | 0 | 0 | 0 |
| 5/18/01 | N/A | 0 | 0 | 0 | 0 |
| 5/19/01 | N/A | 0 | 0 | 0 | 0 |
| 5/20/01 | N/A | 0 | 0 | 1 | 1 |
| 5/21/01 | N/A | 0 | 0 | 0 | 1 |
| 5/22/01 | N/A | 0 | 0 | 0 | 1 |
| 5/23/01 | N/A | 0 | 0 | 0 | 1 |
| 5/24/01 | N/A | 1 | 1 | 0 | 1 |
| 5/25/01 | N/A | 3 | 4 | 0 | 1 |
| 5/26/01 | N/A | 4 | 8 | 0 | 1 |
| 5/27/01 | N/A | 4 | 12 | 0 | 1 |
| 5/28/01 | N/A | 4 | 16 | 0 | 1 |
| 5/29/01 | N/A | 0 | 16 | 0 | 1 |
| 5/30/01 | N/A | 1 | 17 | 0 | 1 |
| 5/31/01 | N/A | 0 | 17 | 0 | 1 |
| 6/1/01 | N/A | 2 | 19 | 0 | 1 |
| 6/2/01 | N/A | 0 | 19 | 0 | 1 |
| 6/3/01 | N/A | 3 | 22 | 0 | 1 |
| 6/4/01 | N/A | 0 | 22 | 0 | 1 |
| 6/5/01 | N/A | 1 | 23 | 0 | 1 |
| 6/6/01 | 14.28 | 0 | 23 | 0 | 1 |
| 6/7/01 | 17.28 | 1 | 24 | 0 | 1 |
| 6/8/01 | 18.57 | 1 | 25 | 0 | 1 |
| 6/9/01 | 19.06 | 1 | 26 | 0 | 1 |
| 6/10/01 | 14.91 | 0 | 26 | 0 | 1 |
| 6/11/01 | 12.42 | 0 | 26 | 0 | 1 |
| 6/12/01 | 12.11 | 1 | 27 | 1 | 2 |
| 6/13/01 | 18.73 | 0 | 27 | 0 | 2 |
| 6/14/01 | 19.55 | 1 | 28 | 0 | 2 |
| 6/15/01 | 19.71 | 0 | 28 | 0 | 2 |
| 6/16/01 | 20.36 | 4 | 32 | 0 | 2 |
| 6/17/01 | 17.28 | 2 | 34 | 0 | 2 |
| 6/18/01 | 19.22 | 2 | 36 | 0 | 2 |
| 6/19/01 | 21.01 | 2 | 38 | 0 | 2 |
| 6/20/01 | 22.17 | 1 | 39 | 0 | 2 |
| 6/21/01 | 23.69 | 7 | 46 | 0 | 2 |
| 6/22/01 | 23.35 | 9 | 55 | 0 | 2 |
| 6/23/01 | 20.84 | 2 | 57 | 0 | 2 |
| 6/24/01 | 13.04 | 3 | 60 | 0 | 2 |
| 6/25/01 | 16.02 | 0 | 60 | 0 | 2 |
| 6/26/01 | 18.73 | 0 | 60 | 0 | 2 |
| 6/27/01 | 14.91 | 0 | 60 | 0 | 2 |
| 6/28/01 | 20.19 | 0 | 60 | 0 | 2 |
| 6/29/01 | 22.17 | 0 | 60 | 0 | 2 |
| 6/30/01 | 21.34 | 0 | 60 | 0 | 2 |
| 7/1/01 | 23.87 | 0 | 60 | 0 | 2 |
| 7/2/01 | 24.73 | 0 | 60 | 0 | 2 |
| 7/3/01 | 23.18 | 0 | 60 | 0 | 2 |
| 7/4/01 | 25.42 | 0 | 60 | 0 | 2 |

| DATE | TEMPERATURE °C | UPSTREAM COUNT DAILY | UPSTREAM TOTAL | DOWNSTREAM COUNT DAILY | DOWNSTREAM TOTAL |
|---|---|---|---|---|---|
| 7/5/01 | 21.17 | 3 | 63 | 0 | 2 |
| 7/6/01 | 24.56 | 1 | 64 | 2 | 4 |
| 7/7/01 | 21.17 | 0 | 64 | 0 | 4 |
| 7/8/01 | 23.01 | 1 | 65 | 0 | 4 |
| 7/9/01 | 22.34 | 0 | 65 | 0 | 4 |
| 7/10/01 | 19.71 | 0 | 65 | 0 | 4 |
| 7/11/01 | 24.73 | 0 | 65 | 1 | 5 |
| 7/12/01 | 22.51 | 0 | 65 | 1 | 6 |
| 7/13/01 | 21.34 | 0 | 65 | 0 | 6 |
| 7/14/01 | 22.01 | 0 | 65 | 2 | 8 |
| 7/15/01 | 22.34 | 0 | 65 | 0 | 8 |
| 7/16/01 | 20.03 | 0 | 65 | 0 | 8 |
| 7/17/01 | 18.25 | 0 | 65 | 0 | 8 |
| 7/18/01 | 17.28 | 0 | 65 | 0 | 8 |
| 7/19/01 | 19.55 | 1 | 66 | 0 | 8 |
| 7/20/01 | 18.09 | 0 | 66 | 0 | 8 |
| 7/21/01 | 18.41 | 0 | 66 | 0 | 8 |
| 7/22/01 | 22.17 | 0 | 66 | 0 | 8 |
| 7/23/01 | 22.01 | 0 | 66 | 0 | 8 |
| 7/24/01 | 23.18 | 0 | 66 | 1 | 9 |
| 7/25/01 | 22.34 | 0 | 66 | 0 | 9 |
| 7/26/01 | 22.34 | 1 | 67 | 0 | 9 |
| 7/27/01 | 22.34 | 0 | 67 | 0 | 9 |
| 7/28/01 | 21.17 | 0 | 67 | 0 | 9 |
| 7/29/01 | 17.12 | 0 | 67 | 1 | 10 |
| 7/30/01 | 15.86 | 0 | 67 | 0 | 10 |
| 7/31/01 | 19.38 | 0 | 67 | 0 | 10 |
| 8/1/01 | 21.01 | 0 | 67 | 0 | 10 |
| 8/2/01 | 22.17 | 0 | 67 | 0 | 10 |
| 8/3/01 | 21.17 | 0 | 67 | 0 | 10 |
| 8/4/01 | 17.28 | 0 | 67 | 0 | 10 |
| 8/5/01 | 21.84 | 0 | 67 | 0 | 10 |
| 8/6/01 | 23.18 | 0 | 67 | 0 | 10 |
| 8/7/01 | 24.04 | 0 | 67 | 0 | 10 |
| 8/8/01 | 23.35 | 0 | 67 | 0 | 10 |
| 8/9/01 | 19.71 | 0 | 67 | 0 | 10 |
| 8/10/01 | 21.01 | 0 | 67 | 0 | 10 |
| 8/11/01 | 22.67 | 0 | 67 | 0 | 10 |
| 8/12/01 | 20.52 | 0 | 67 | 0 | 10 |
| 8/13/01 | 21.84 | 0 | 67 | 0 | 10 |
| 8/14/01 | 19.22 | 0 | 67 | 0 | 10 |
| 8/15/01 | 23.01 | 0 | 67 | 0 | 10 |
| 8/16/01 | 22.01 | 0 | 67 | 0 | 10 |
| 8/17/01 | 22.67 | 0 | 67 | 1 | 11 |
| 8/18/01 | 21.84 | 0 | 67 | 0 | 11 |
| 8/19/01 | 20.68 | 0 | 67 | 0 | 11 |
| 8/20/01 | 20.19 | 0 | 67 | 0 | 11 |
| 8/21/01 | 20.36 | 0 | 67 | 0 | 11 |
| 8/22/01 | 20.03 | 0 | 67 | 0 | 11 |
| 8/23/01 | 17.44 | 0 | 67 | 0 | 11 |
| 8/24/01 | 20.19 | 0 | 67 | 0 | 11 |
| 8/25/01 | 20.03 | 0 | 67 | 0 | 11 |

| DATE | TEMPERATURE °C | UPSTREAM COUNT DAILY | UPSTREAM TOTAL | DOWNSTREAM COUNT DAILY | DOWNSTREAM TOTAL |
|---|---|---|---|---|---|
| 8/26/01 | 21.67 | 0 | 67 | 0 | 11 |
| 8/27/01 | 21.67 | 0 | 67 | 0 | 11 |
| 8/28/01 | 21.17 | 0 | 67 | 0 | 11 |
| 8/29/01 | 21.67 | 0 | 67 | 0 | 11 |
| 8/30/01 | 18.57 | 0 | 67 | 0 | 11 |
| 8/31/01 | 20.52 | 0 | 67 | 0 | 11 |
| 9/1/01 | 19.87 | 0 | 67 | 0 | 11 |
| 9/2/01 | 20.68 | 0 | 67 | 0 | 11 |
| 9/3/01 | 20.68 | 0 | 67 | 0 | 11 |
| 9/4/01 | 20.36 | 0 | 67 | 0 | 11 |
| 9/5/01 | 16.02 | 0 | 67 | 0 | 11 |
| 9/6/01 | 15.38 | 0 | 67 | 0 | 11 |
| 9/7/01 | 16.33 | 0 | 67 | 0 | 11 |
| 9/8/01 | 16.33 | 0 | 67 | 0 | 11 |
| 9/9/01 | 16.97 | 0 | 67 | 0 | 11 |
| 9/10/01 | 16.33 | 0 | 67 | 0 | 11 |
| 9/11/01 | 18.41 | 0 | 67 | 0 | 11 |
| 9/12/01 | 17.28 | 0 | 67 | 0 | 11 |
| 9/13/01 | 20.36 | 0 | 67 | 0 | 11 |
| 9/14/01 | 17.12 | 0 | 67 | 0 | 11 |
| 9/15/01 | 15.38 | 0 | 67 | 0 | 11 |
| 9/16/01 | 13.81 | 0 | 67 | 0 | 11 |
| 9/17/01 | 17.93 | 0 | 67 | 2 | 13 |
| 9/18/01 | 17.44 | 0 | 67 | 0 | 13 |
| 9/19/01 | 15.54 | 0 | 67 | 0 | 13 |
| 9/20/01 | 16.02 | 0 | 67 | 0 | 13 |
| 9/21/01 | 15.07 | 1 | 68 | 0 | 13 |
| 9/22/01 | 16.49 | 0 | 68 | 0 | 13 |
| 9/23/01 | 15.86 | 0 | 68 | 0 | 13 |
| 9/24/01 | 15.86 | 0 | 68 | 0 | 13 |
| 9/25/01 | 11.19 | 0 | 68 | 0 | 13 |
| 9/26/01 | 13.66 | 0 | 68 | 0 | 13 |
| 9/27/01 | 15.70 | 0 | 68 | 0 | 13 |
| 9/28/01 | 13.51 | 0 | 68 | 0 | 13 |
| 9/29/01 | 14.43 | 0 | 68 | 0 | 13 |
| 9/30/01 | 14.75 | 0 | 68 | 0 | 13 |
| 10/1/01 | 15.23 | 0 | 68 | 0 | 13 |
| 10/2/01 | 14.91 | 0 | 68 | 0 | 13 |
| 10/3/01 | 14.28 | 0 | 68 | 0 | 13 |
| 10/4/01 | 13.81 | 0 | 68 | 0 | 13 |
| 10/5/01 | 12.42 | 0 | 68 | 0 | 13 |
| 10/6/01 | 12.58 | 0 | 68 | 0 | 13 |
| 10/7/01 | 8.86 | 0 | 68 | 0 | 13 |
| 10/8/01 | 9.78 | 0 | 68 | 0 | 13 |
| 10/9/01 | 9.32 | 0 | 68 | 0 | 13 |
| 10/10/01 | 6.23 | 0 | 68 | 0 | 13 |
| 10/11/01 | 7.63 | 0 | 68 | 0 | 13 |
| 10/12/01 | 7.47 | 0 | 68 | 0 | 13 |
| 10/13/01 | 11.34 | 0 | 68 | 0 | 13 |
| 10/14/01 | 10.88 | 0 | 68 | 0 | 13 |
| 10/15/01 | 9.78 | 0 | 68 | 0 | 13 |
| 10/16/01 | 8.09 | 0 | 68 | 0 | 13 |

| DATE | TEMPERATURE °C | UPSTREAM COUNT DAILY | UPSTREAM TOTAL | DOWNSTREAM COUNT DAILY | DOWNSTREAM TOTAL |
|---|---|---|---|---|---|
| 10/17/01 | 9.17 | 0 | 68 | 0 | 13 |
| 10/18/01 | 8.09 | 0 | 68 | 0 | 13 |
| 10/19/01 | 10.41 | 0 | 68 | 0 | 13 |
| 10/20/01 | 9.63 | 0 | 68 | 0 | 13 |
| 10/21/01 | 7.63 | 0 | 68 | 0 | 13 |
| 10/22/01 | 7.78 | 0 | 68 | 0 | 13 |
| 10/23/01 | 6.39 | 0 | 68 | 1 | 14 |
| 10/24/01 | 6.54 | 0 | 68 | 0 | 14 |
| 10/25/01 | 7.94 | 0 | 68 | 0 | 14 |
| 10/26/01 | 8.55 | 0 | 68 | 0 | 14 |

# Entrainment of Bull Trout at Agency Valley Dam

## 2001

AUTHOR: JASON FENTON, BURNS PAIUTE TRIBE FISH AND WILDLIFE DEPARTMENT

The United States Bureau of Reclamation, Oregon Department of Fish and Wildlife, and the Burns Paiute Tribe have determined that bull trout *Salvenlinus confluentus* entrainment occurs over the Agency Valley Dam through its spillway (Schwabe 2000). Bull trout are listed as a threatened species due to past land management activities, which include the construction of dams and fish eradication projects by poisoning (Bowers et al. 1993).

In 1998 and 1999, a migration study on bull trout was conducted. In both years, radio tagged bull trout were observed in Beulah Reservoir and the North Fork Malheur River from mid April to late May (Schwabe 2000). The Vale Irrigation District, for flood control, initiated releases of water from the reservoir in mid-March. During the periods of water release, there was a risk of bull trout entrainment through the Agency Valley Dam. Bull trout were still being observed in the reservoir from mid-March through June. In previous research, bull trout have been documented leaving the reservoir during these periods of irrigation withdrawals and returning from post spawning/migration activities prior to cessation of water releases.

Currently, there are no fish passage facilities at Agency Valley Dam for upstream migrating or entrained fish. During 1998 and 1999, water was released over the spillway. This resulted in the entrainment of radio tagged bull trout from the reservoir. Changes in the 2000 irrigation season resulted in the release of water through the flow valves rather than over the spillway in an effort to reduce the number of entrained bull trout. The Burns Paiute Tribe and partners developed the following objectives for this study:

1) Identify bull trout entrainment in response to water management activities.

2) Determine if the release of water from the flow valves will reduce the rate of entrainment of radio tagged fish in comparison to traditional water management practices.

This report consists of cumulative data since the water release practices have changed.

## Methods

Creel surveys were conducted three times a week in the spring from mid-March to mid-July and in the fall from August to October 2001. All anglers within ¼ mile below the dam were surveyed. The surveys consisted of recording catch per effort (number of fish per hour) for the total hours fished per angler. Burns Paiute Tribe employees angled while they surveyed other fishermen. Any bull trout that were angled by employees were placed in a bucket with an aerator and transported above the dam to be released in the reservoir.

## Results

In the spring of 2001, no bull trout were observed angled below Beulah reservoir. Only 13 rainbow trout *Oncorhynchus mykiss* were observed during this same time period (Table 18). Other species angled below the reservoir include: Sucker *Catostomus spp*., Chiselmouth *Acrocheilus alutaceus*, and Northern Pike Minnow *Ptychocheilus oregonensis*.
In the fall of 2001, no bull trout were observed angled below the reservoir. Rainbow trout catch increased to 34. The only other fish species to be angled in the fall was northern pike minnow.

Table 18. Catch rate (#/hour) for 1999, 2000, and 2001.

| | # Fish Caught in Spring | | # Fish Caught in Fall | |
|---|---|---|---|---|
| | Bull Trout | Rainbow Trout | Bull Trout | Rainbow Trout |
| 1999 | 20 | 150 | Na* | Na* |
| 2000 | 5 | 107 | 0 | 4 |
| 2001 | 0 | 13 | 0 | 34 |
| | Catch Rate (#/hour) for Spring | | Catch Rate (#/hour) for Fall | |
| | Bull Trout | Rainbow Trout | Bull Trout | Rainbow Trout |
| 1999 | 0.05 | 0.34 | Na* | Na* |
| 2000 | 0.01 | 0.21 | 0.00 | 0.02 |
| 2001 | 0.00 | 0.08 | 0.00 | 0.59 |

* No creel in fall of 1999.

## Discussion

In 2000 and 2001, water was released from the reservoir through the flow valves at the bottom of the dam. In the fall of 2001, unknown species of fish were observed coming out of the flow valves (Personal observation of Tribal employees). It is assumed that since the reservoir was lowered down to the minimum pool the fish were concentrated near the upper opening of the tubes and had a greater chance

than the year before to become entrained. As a result of this, the rainbow trout catch rate in the fall increased compared to the previous years study. No bull trout were observed to be angled in the spring or the fall of 2001. Previous studies (Schwabe 2000) suggest that adult bull trout migrate into Beulah Reservoir in November and December. Since water releases cease in mid October, adult bull trout prior to water shut off are more likely in the North Fork Malheur River above the reservoir and less susceptible to fall entrainment. This may help to explain why there were no bull trout observed below the dam. It is unknown if juvenile bull trout reside in the reservoir year round. Since angling is size selective, small bull trout that were entrained, most likely would not be caught with hook and line. The Burns Paiute Tribe and partners are currently conducting a study of juvenile bull trout to help managers determine the best water management practices for the survival of bull trout. Creel surveys will be conducted in the spring and fall of 2002 to continue monitoring salmonid catches below Agency Valley Dam.

## References

Bowers, W.L., P.A. Dupee, M.L. Hanson, and R.R. Perkins. 1993 Bull Trout Populations Summary Malheur River Basin. Oregon Department of Fish and Wildlife, Hines, Oregon. Unpublished report.

Schwabe, L.T. 2000 Malheur River Basin Cooperative Bull Trout/Redband Trout Research Project. Use of Radio Telemetry to Document Movements of Bull Trout in the Malheur Basin in Oregon. Fiscal Year 1999 Annual Report. Unplublished Data. Burns Paiute Tribe Fish and Wildlife Department. Burns, Oregon.

# Population Estimate of Salmonids in McCoy Creek

## 2001

AUTHOR: JASON FENTON, BURNS PAIUTE TRIBE FISH AND WILDLIFE DEPARTMENT

McCoy Creek is a tributary of Lake Creek in the Upper Malheur River Basin. There have been no intense studies to document bull trout *Salvelinus confluentus* in McCoy Creek. The objectives of this study are:

1) Determine the presence/absence of bull trout.
2) Estimate the population size of rainbow trout *Oncorhynchus mykiss* and brook trout *Salvelinus fontinalis.*

## Methods

### 2001 Electrofishing Protocol

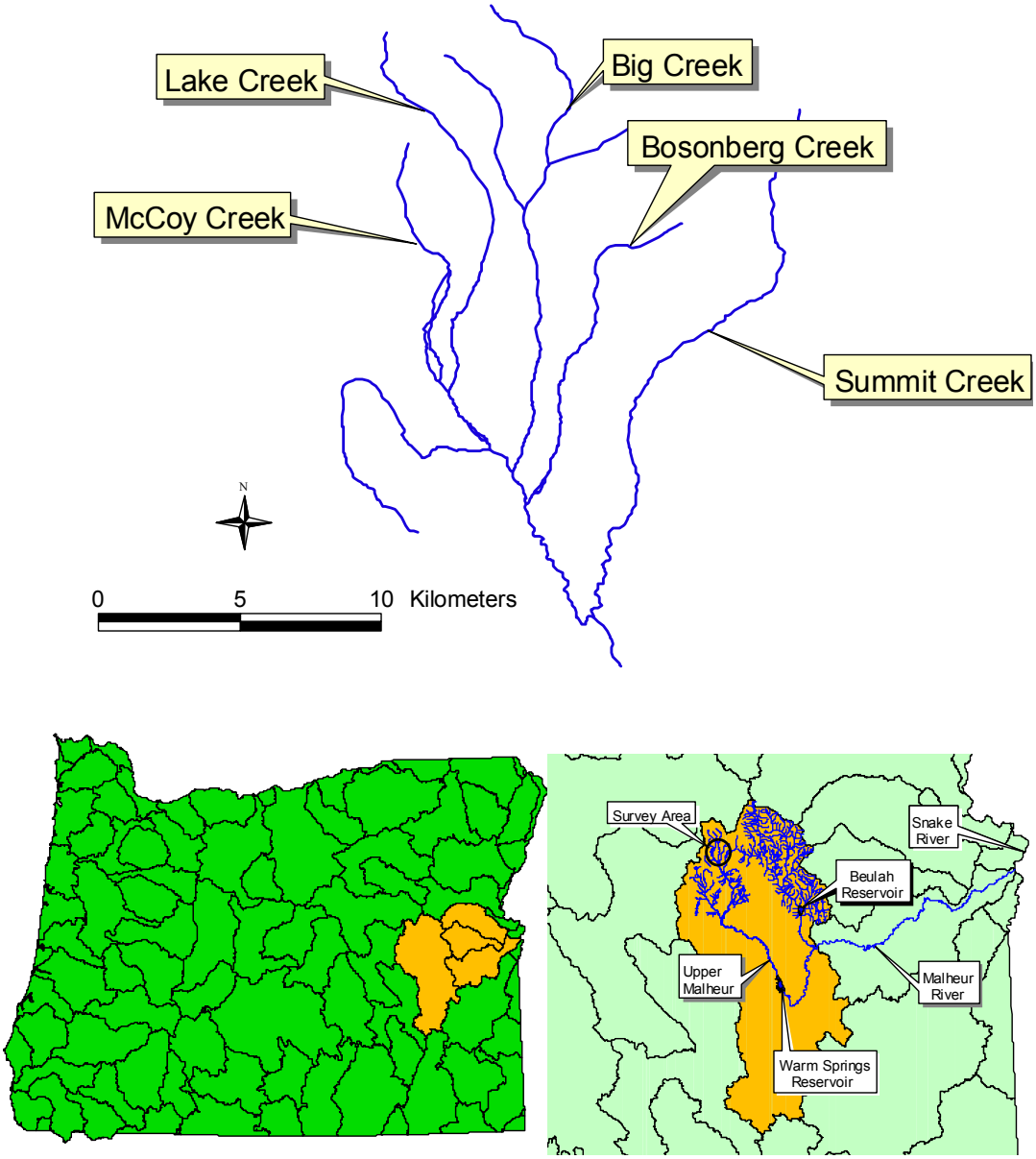
The BPT conducted a 2/4 pass 50% reduction population survey on McCoy Creek (Figure 4). Sites were to be 50 meters in length (164 feet). Block nets were anchored into the substrate with tent pegs and rocks at the upper and lower boundary to prevent fish escapement. Survey unit #1 began at the mouth where McCoy Creek drains into Lake Creek. Sites were separated by 200-meter sections of stream. One pass consisted of shocking from the lower block net up to the upper block net and back down. The second pass must have a 50% reduction in the collection of age 1+ (fork length≥70 mm) rainbow and brook trout for the site to be complete. If this was not met, 2 more passes were required using the same methodology. The last site for the population survey was determined when no salmonids were collected on the first pass. From this site, upper limits of brook and rainbow trout were determined by shocking 100% of the wetted channel upstream until the channel became dry or intermittent.

Achieving 50% reduction for bull trout was not necessary because the goal was to determine presence/absence only.

### Fish collection

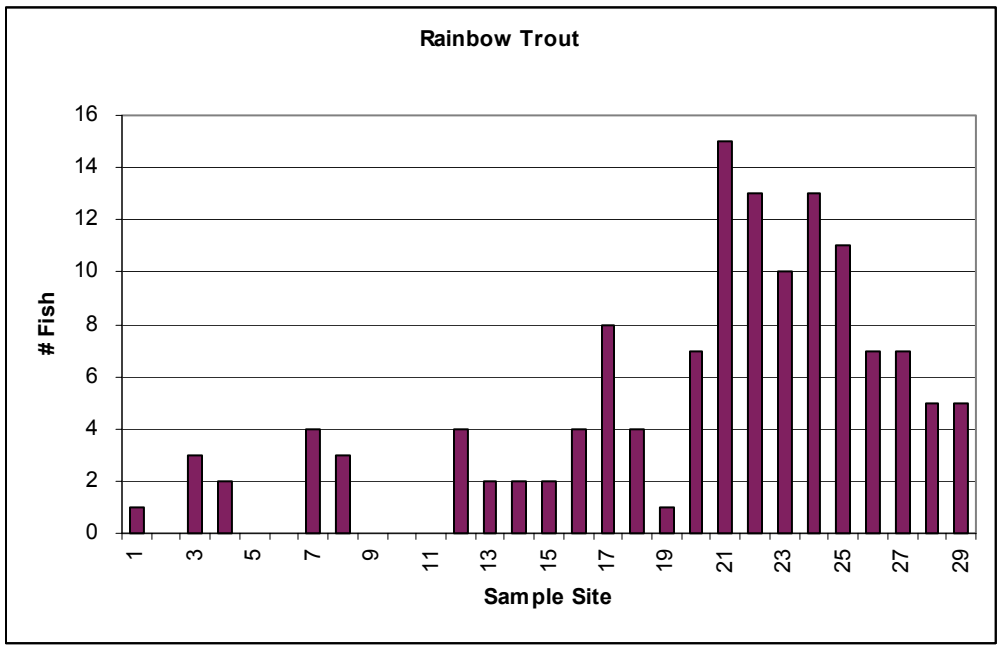
Fish collection was accomplished with the use of a Smith & Root electrofisher. The protocol for shocking was to start at the down stream end of the block nets and shock moving upstream. Shocking was accomplished in groups of three, one person operating the shocker, and two netters to the side. If fish were not observed reacting to the set electrical current, instruments on the shocker were adjusted to increase the impact. Once the first pass was complete, fish were counted and sorted by species. Fish lengths (fork length mm) and weights (g) were measured and recorded. This procedure was repeated for all passes. The percentage of fish captured on the second pass was calculated and compared to fish captured on the first pass to determine if the process needed to be repeated again to reach the 50% reduction for salmonids.

Figure 4. Location of McCoy Creek in the Upper Malheur Basin, Oregon 2001.



# Results

## Rainbow Trout *Oncorhynchus mykiss*

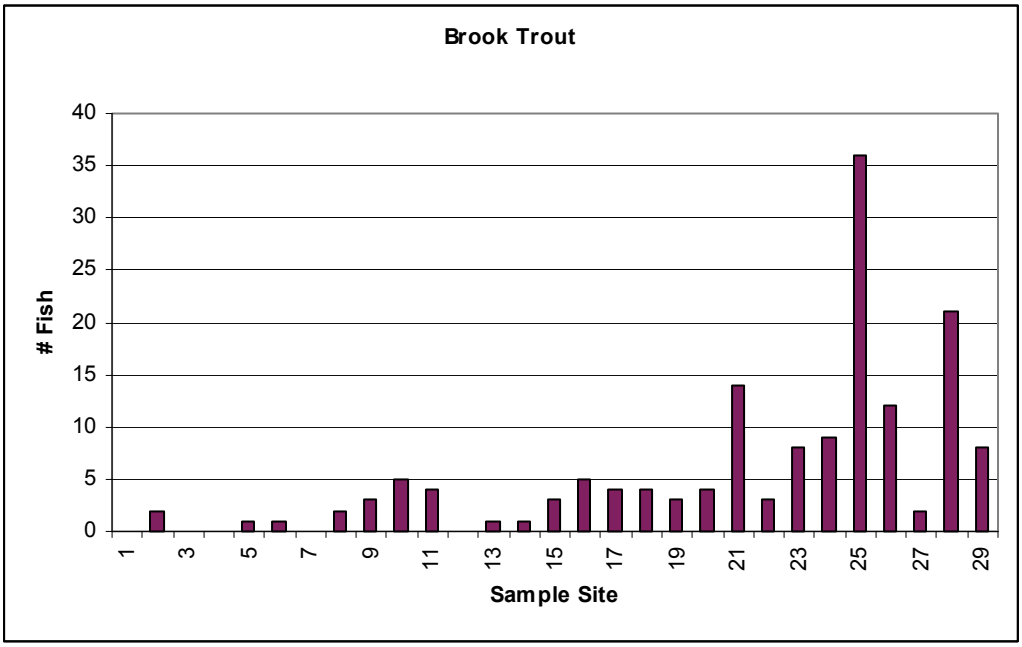



There were a total of 29 sampled units with 1+ (70+mm fork length) rainbow trout being observed in 24 units. A 50% reduction was achieved at every sample unit. There were 133 rainbow trout sampled with the average probability of capture being 94% and the probability of non-capture of 6%. Of the total survey area 21% was sampled. The estimated population of rainbow trout for McCoy Creek was 634 +/- 242 with a 95% confidence level (Table 19).

Table 19. Population Estimate for 1+ Rainbow Trout in McCoy Creek 2001.

| McCoy Creek | | Rainbow 1+ | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Fish per square meter | | Fish per lineal meter | |
| Habitat type | Population estimate | +/- 95% c.l. | CL % of estimate | Habitat type | Reach average | Habitat type | Reach average |
| mix | 634 | 242 | 0.381703 | 0.0753 | Na | 0.089 | Na |
| Total | 634 | 242 | 0.381703 | 0.0753 | Na | 0.089 | Na |

## **Brook Trout** *Salvelinus fontinalis*

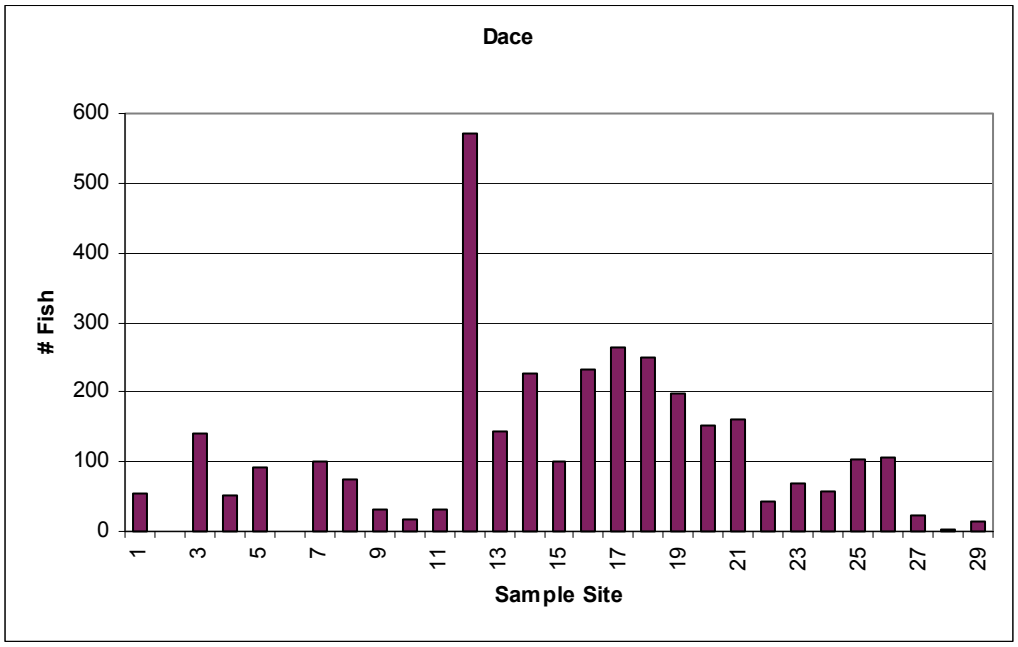



In McCoy Creek, 1+ brook trout were observed in 24 sample units. A 50% reduction was achieved at all sample sites. There were 156 brook trout sampled with the average probability of capture being 92% and a probability of non-capture of 8%. Of the total survey area 21% was sampled. The estimated population of brook trout in McCoy Creek was 743 +/- 393 with a 95% confidence level (Table 20).

Table 20. Population Estimate for 1+ Brook Trout in McCoy Creek 2001.

| McCoy Creek | | Brook 1+ | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Fish per square meter | | Fish per lineal meter | |
| Habitat type | Population estimate | +/- 95% c.l. | CL % of estimate | Habitat type | Reach average | Habitat type | Reach average |
| mix | 743 | 393 | 0.528937 | 0.0882 | Na | 0.105 | Na |
| Total | 743 | 393 | 0.528937 | 0.0882 | Na | 0.105 | Na |

## **Dace** *Rhinichthys spp.*

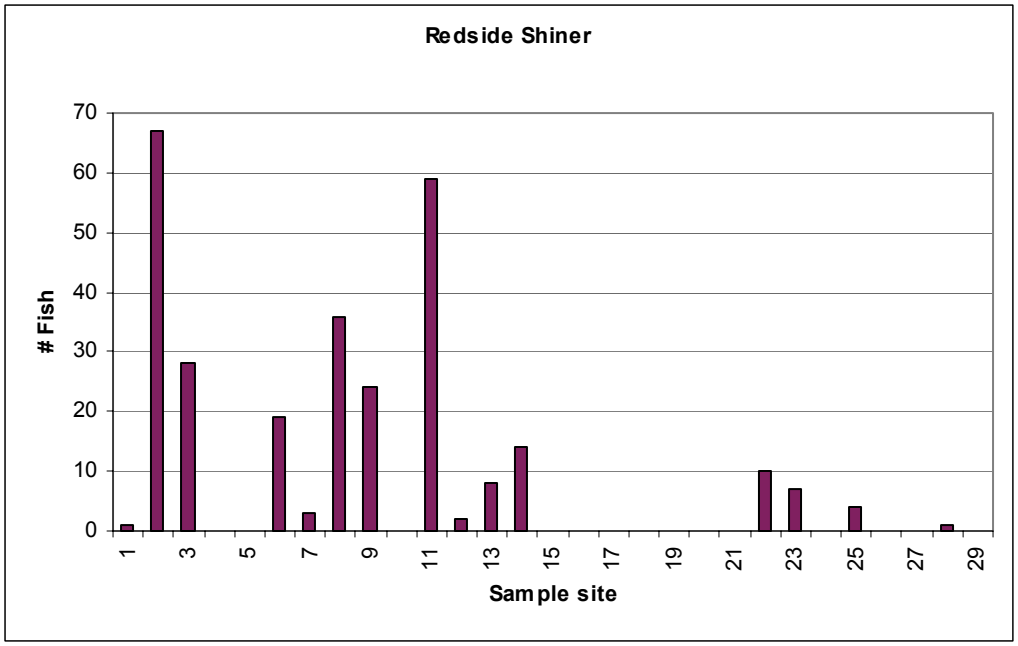



Speckled Dace *Rhinichthys osculus,* and Long Nose Dace *Rhinichthys cataractae,* were observed throughout McCoy Creek. Both species were calculated together. A 50% reduction was not achieved at all sample sites because it was not a requirement of the protocol. When making assumptions about population estimates only the sample units that achieved a 50% reduction should be used. Sample units 2 and 6 were removed from the data set to be consistent with the established protocol (Dambacher 1997). There were 3310 dace sampled with the average probability of capture being 78% and a probability of non-capture of 22%. The estimated population of dace in McCoy Creek was 16427 +/- 6416 with a 95% confidence level (Table 21).

Table 21. Population Estimate for Dace in McCoy Creek 2001.

| McCoy Creek | | Dace | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Fish per square meter | | Fish per lineal meter | |
| Habitat type | Population estimate | +/- 95% c.l. | CL % of estimate | Habitat type | Reach average | Habitat type | Reach average |
| mix | 16427 | 6416 | 0.390576 | 1.95 | Na | 2.314 | Na |
| Total | 16427 | 6416 | 0.390576 | 1.95 | Na | 2.314 | Na |

## **Redside Shiner** *Richardsonius balteatus*

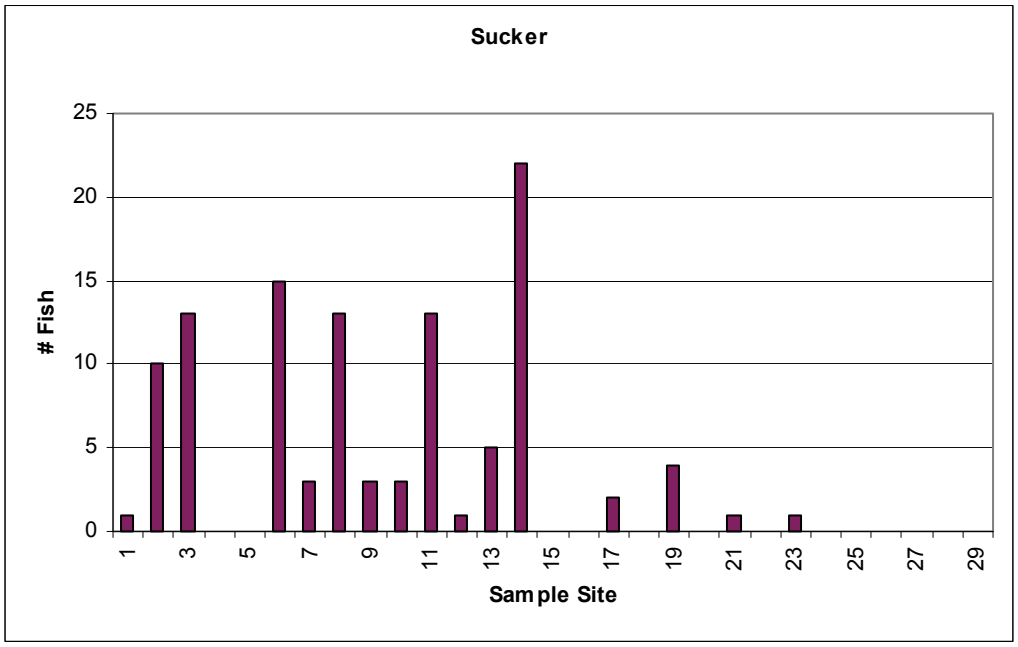



Redside Shiners were observed throughout McCoy Creek. A 50% reduction was not achieved at all sample sites because it was not a requirement of the protocol. When making assumptions about population estimates only the sample units that achieved a 50% reduction should be used. Sample units 4 and 5 were removed from the data set to be consistent with the established protocol (Dambacher 1997). There were 283 redside shiners sampled with the average probability of capture being 75% and a probability of non-capture of 25%. The estimated population of redside shiner in McCoy Creek was 1428 +/- 882 with a 95% confidence level (Table 22).

Table 22. Population Estimate for Redside Shiner in McCoy Creek 2001.

| McCoy Creek | | Redside Shiner | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Fish per square meter | | Fish per lineal meter | |
| Habitat type | Population estimate | +/- 95% c.l. | CL % of estimate | Habitat type | Reach average | Habitat type | Reach average |
| mix | 1428 | 882 | 0.617647 | 0.1695 | Na | 0.201 | Na |
| Total | 1428 | 882 | 0.617647 | 0.1695 | Na | 0.201 | Na |

## **Sucker** *Catostomus spp.*

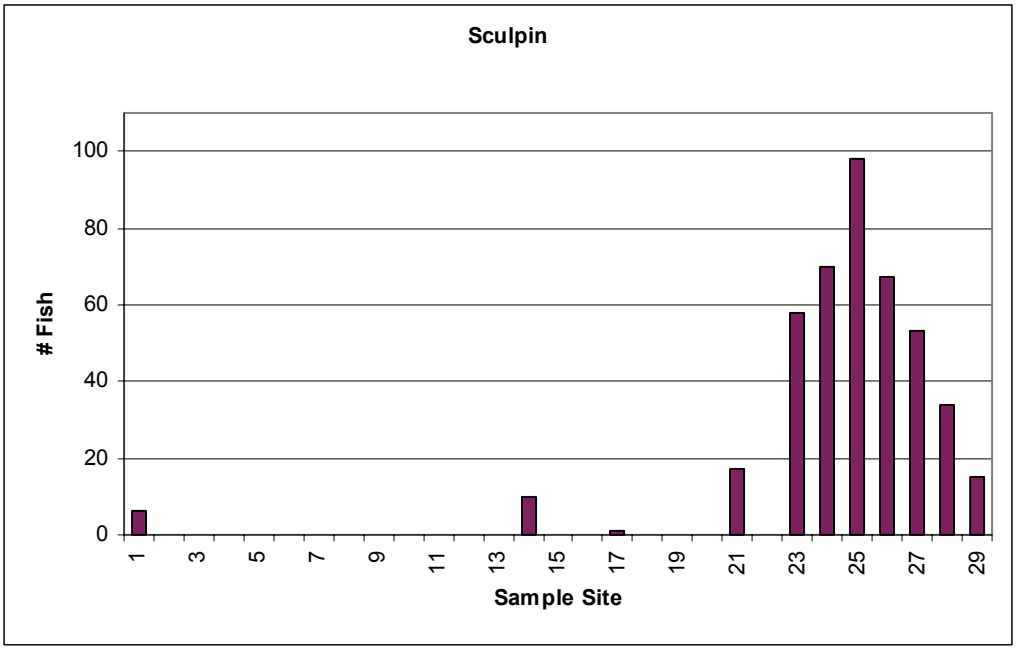



Suckers were observed throughout McCoy Creek but were most abundant in the middle regions of the creek. A 50% reduction was achieved at all sample sites even though it was not a requirement of the protocol. There were 110 suckers sampled with the average probability of capture being 83% and a probability of non-capture of 17%. The estimated population of suckers in McCoy Creek was 534 +/- 300 with a 95% confidence level (Table 23).

Table 23. Population Estimate for Sucker in McCoy Creek 2001.

| McCoy Creek | | Sucker | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Fish per square meter | | Fish per lineal meter | |
| Habitat type | Population estimate | +/- 95% c.l. | CL % of estimate | Habitat type | Reach average | Habitat type | Reach average |
| mix | 534 | 300 | 0.561798 | 0.0634 | Na | 0.075 | Na |
| Total | 534 | 300 | 0.561798 | 0.0634 | Na | 0.075 | Na |

## **Sculpin** *Cottus spp.*




Sculpin were observed mainly in the upper reaches of McCoy Creek. A 50% reduction was not achieved at all sample sites because it was not a requirement of the protocol. When making assumptions about population estimates only the sample units that achieved a 50% reduction should be used. Sample units 2, 16 and 22 were removed from the data set to be consistent with the established protocol (Dambacher 1997). There were 429 Sculpin sampled with the average probability of capture being 74% and a probability of non-capture of 26%. The estimated population of Sculpin in McCoy Creek was 2180 +/- 1464 with a 95% confidence level (Table 24).

Table 24. Population Estimate for Sculpin in McCoy Creek 2001.

| McCoy Creek | | Sculpin | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Fish per square meter | | Fish per lineal meter | |
| Habitat type | Population estimate | +/- 95% c.l. | CL % of estimate | Habitat type | Reach average | Habitat type | Reach average |
| mix | 2180 | 1464 | 0.67156 | 0.2588 | Na | 0.307 | Na |
| Total | 2180 | 1464 | 0.67156 | 0.2588 | Na | 0.307 | Na |

### Bull Trout

No bull trout were observed within the 29 sample sites of McCoy Creek.

### Upper Limits

The upper limit of fish was not found due to the stream freezing over before work could be completed.

## Discussion

Salmonids were the focus of this population study. The majority of rainbow and brook trout were found in the upper reaches of McCoy Creek. This might be due to the higher water temperatures and lesser water quality in the lower reaches. The lower reaches of McCoy Creek are heavily influenced by cattle grazing. There were no bull trout sampled in McCoy Creek even though Lake Creek, which McCoy flows into, does have a population of bull trout. There is no known reason for the lack of bull trout in McCoy Creek. The upper reaches of McCoy Creek appear to have suitable habitat for bull trout.

The McCoy Creek population estimate survey has provided some good base line information on what species are present in the system as well as where they reside spatially. This information will be beneficial for managers and landowners when making decisions that will possibly affect the landscape.

## References

Dambacher, J.M. 1997. Electrofishing Population Estimation Spreadsheet. Version 2.0

# Population Estimate of Salmonids in Summit Creek

**2001**

AUTHOR: JASON FENTON, BURNS PAIUTE TRIBE FISH AND WILDLIFE DEPARTMENT

Summit Creek is a tributary of the Upper Malheur River flowing in at river kilometer 299. There has been limited documentation of bull trout Salvelinus confluentus in Summit Creek in the past. The objectives of this study are:

1. Determine the presence/absence of bull trout.
2. Estimate the population size of rainbow Oncorhynchus mykiss and brook trout Salvelinus fontinalis.

## Methods

### 2001 Electrofishing Protocol

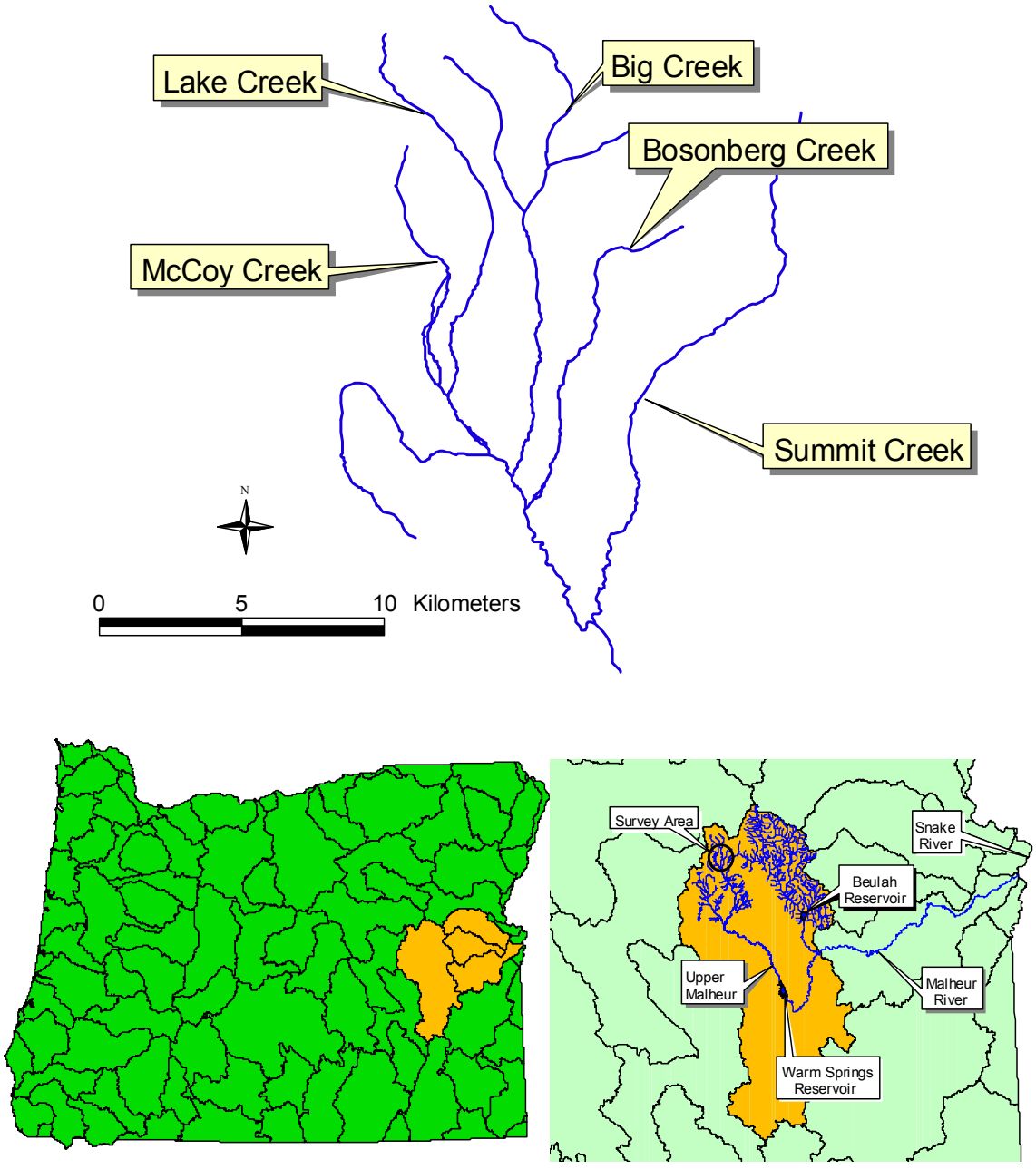
The BPT conducted a 2/4 pass 50% reduction population survey on Summit Creek (Figure 5). Sites were to be 50 meters in length (164 feet). Block nets were anchored into the substrate with tent pegs and rocks at the upper and lower boundary to prevent fish escapement. Survey unit #1 began at the mouth of Summit where it flows into the Upper Malheur River. Sites were separated by 500-meter (1640 feet) sections of stream. One pass consisted of shocking from the lower block net up to the upper block net and back down. The second pass must have a 50% reduction in the collection of age 1+ (fork length>70 mm) rainbow and brook trout for the site to be complete. If this was not met, 2 more passes were required using the same methodology. The last site for the population survey was determined when no salmonids were collected on the first pass. From this site, upper limits of brook and rainbow trout were determined by shocking 100% of the wetted channel upstream until the channel became dry or intermittent.

Achieving 50% reduction for bull trout was not necessary because the goal was to determine presence/absence only.

### Fish collection

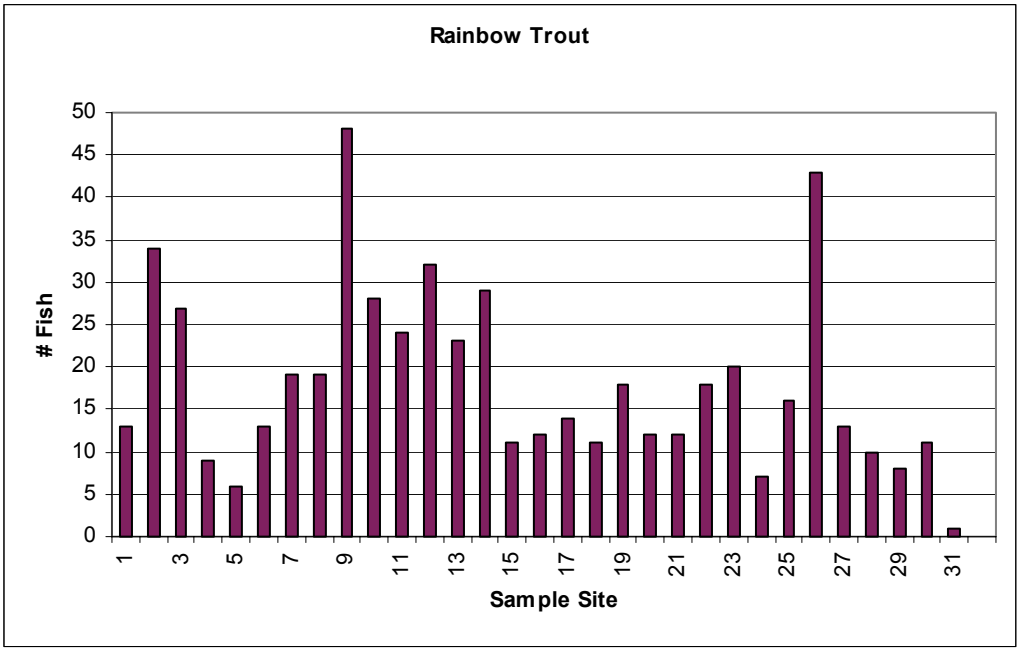
Fish collection was accomplished with the use of a Smith & Root electrofisher. The protocol for shocking was to start at the down stream end of the block nets and shock moving upstream. Shocking was accomplished in groups of three, one person operating the shocker, and two netters to the side. If fish were not observed reacting to the set electrical current, instruments on the shocker were adjusted to increase the impact. Once the first pass was complete, fish were counted and sorted by species. Fish lengths (fork length mm) and weights (g) were measured and recorded. This procedure was repeated for all passes. The percentage of fish captured on the second pass was calculated and compared to fish captured on the first pass to determine if the process needed to be repeated again to reach the 50% reduction for salmonids.

Figure 5. Location of Summit Creek in the Upper Malheur Basin, Oregon 2001.



# Results

## Rainbow Trout *Oncorhynchus mykiss*

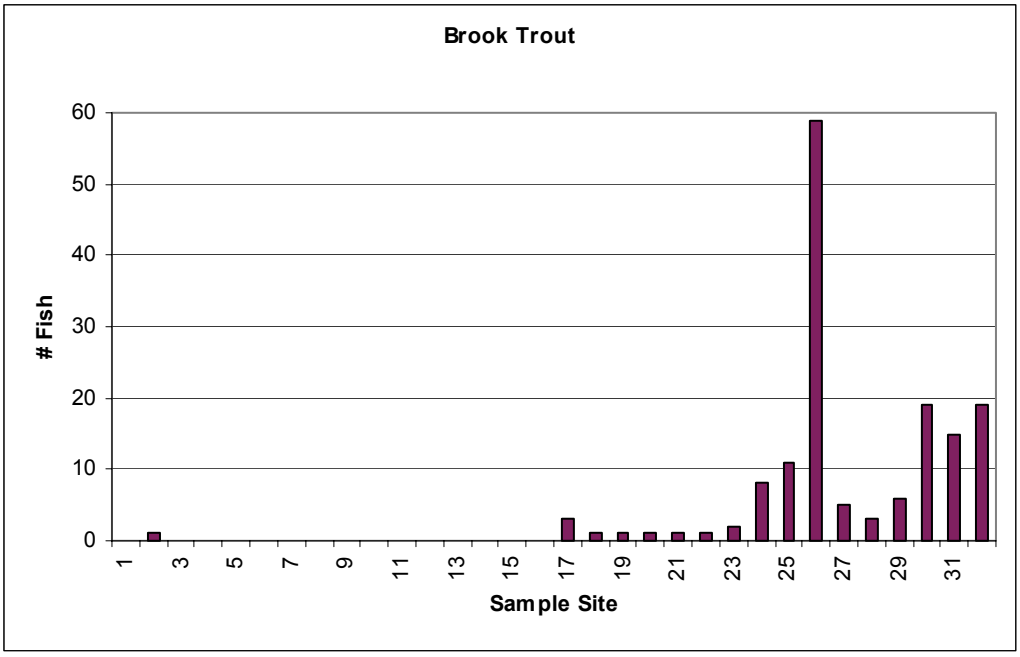



There were a total of 32 sampled units with 1+ (70+mm fork length) rainbow trout being observed in 31 units. A 50% reduction was achieved at every sample unit. There were 561 rainbow trout sampled with the average probability of capture being 82% and the probability of non-capture of 18%. Of the total survey area 7.3% was sampled. The estimated population of rainbow trout for Summit Creek was 7756 +/- 1702 with a 95% confidence level (Table 25).

Table 25. Population Estimate for 1+ Rainbow Trout in Summit Creek 2001.

| Summit Creek | | Rainbow 1+ | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Fish per square meter | | Fish per lineal meter | |
| Habitat type | Population estimate | +/- 95% c.l. | CL % of estimate | Habitat type | Reach average | Habitat type | Reach average |
| Mix | 7756 | 1702 | 0.219443 | 0.141 | Na | 0.353 | Na |
| Total | 7756 | 1702 | 0.219443 | 0.141 | Na | 0.353 | Na |

## **Brook Trout** *Salvelinus fontinalis*

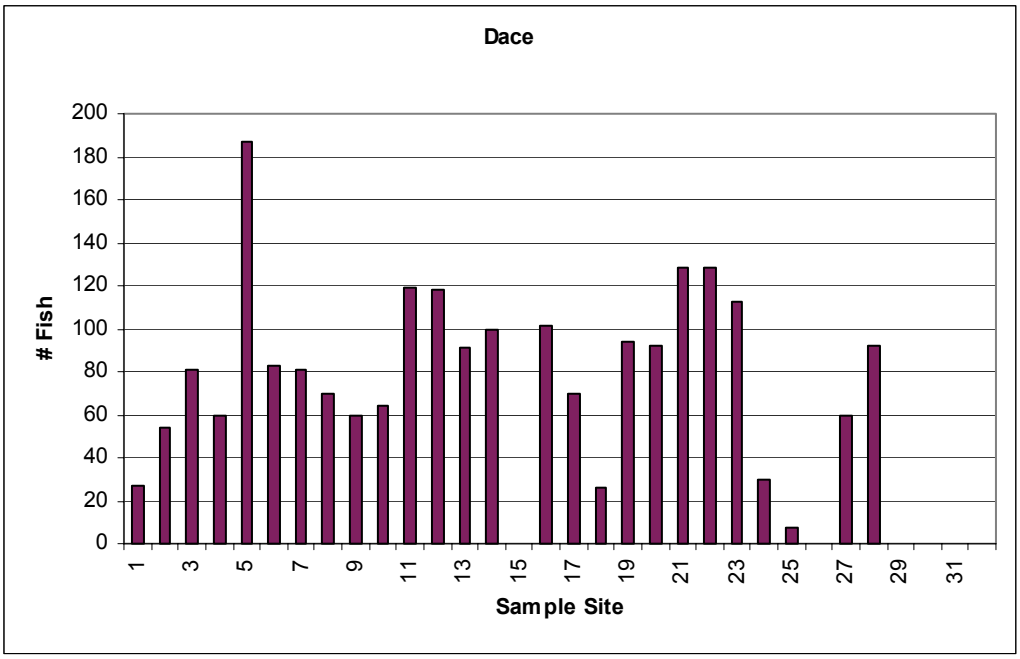



In Summit Creek, 1+ brook trout were observed in 17 sample units. A 50% reduction was achieved at all sample sites. There were 156 brook trout sampled with the average probability of capture being 85% and a probability of non-capture of 15%. Of the total survey area 7.3% was sampled. The estimated population of brook trout in Summit Creek was 2186+/- 1716 with a 95% confidence level (Table 26).

Table 26. Population Estimate for 1+ Brook Trout in Summit Creek 2001.

| Summit Creek | | Brook 1+ | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Fish per square meter | | Fish per lineal meter | |
| Habitat type | Population estimate | +/- 95% c.l. | CL % of estimate | Habitat type | Reach average | Habitat type | Reach average |
| Mix | 2186 | 1716 | 0.784995 | 0.0397 | Na | 0.099 | Na |
| Total | 2186 | 1716 | 0.784995 | 0.0397 | Na | 0.099 | Na |

## **Dace** *Rhinichthys spp.*

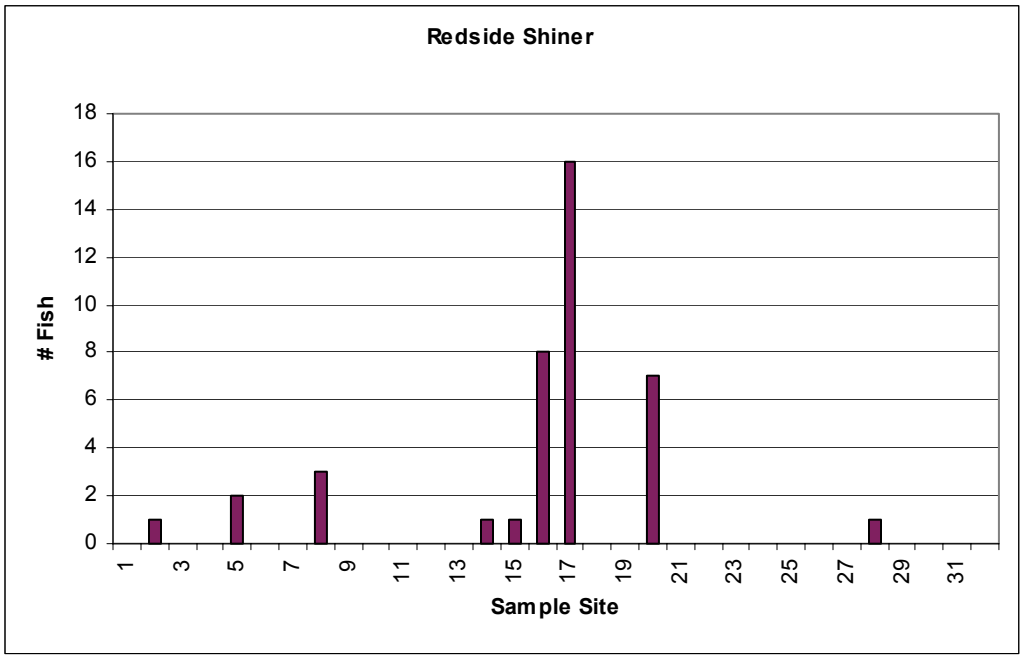



Speckled Dace *Rhinichthys osculus,* and Long Nose Dace *Rhinichthys cataractae* were observed throughout Summit Creek. Both species were calculated together. A 50% reduction was not achieved at all sample sites because it was not a requirement of the protocol. When making assumptions about population estimates only the sample units that achieved a 50% reduction should be used. Sample units 15 and 26 were removed from the data set to be consistent with the established protocol (Dambacher 1997). There were 2136 dace sampled with the average probability of capture being 74% and a probability of non-capture of 26%. The estimated population of dace in Summit Creek was 30610+/- 7519 with a 95% confidence level (Table 27).

Table 27. Population Estimate for Dace in Summit Creek 2001.

| Summit Creek | | Dace | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Fish per square meter | | Fish per lineal meter | |
| Habitat type | Population estimate | +/- 95% c.l. | CL % of estimate | Habitat type | Reach average | Habitat type | Reach average |
| Mix | 30610 | 7519 | 0.245639 | 0.5565 | Na | 1.391 | Na |
| Total | 30610 | 7519 | 0.245639 | 0.5565 | Na | 1.391 | Na |

## **Redside Shiner** *Richardsonius balteatus*

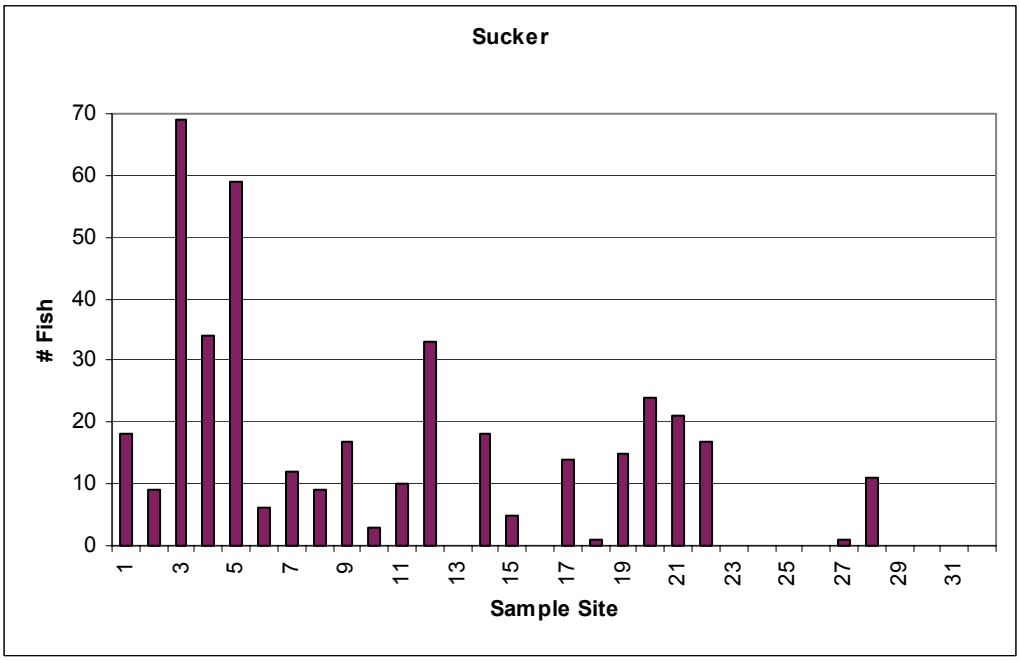



Redside Shiners were observed throughout Summit Creek. A 50% reduction was not achieved at all sample sites because it was not a requirement of the protocol. When making assumptions about population estimates only the sample units that achieved a 50% reduction should be used. Sample unit 18 was removed from the data set to be consistent with the established protocol (Dambacher 1997). There were 40 redside shiners sampled with the average probability of capture being 86% and a probability of non-capture of 14%. The estimated population of redside shiner in Summit Creek was 547+/- 512 with a 95% confidence level (Table 28).

Table 28. Population Estimate for Redside Shiner in Summit Creek 2001.

| Summit Creek | | Redside Shiner | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Fish per square meter | | Fish per lineal meter | |
| Habitat type | Population estimate | +/- 95% c.l. | CL % of estimate | Habitat type | Reach average | Habitat type | Reach average |
| Mix | 547 | 512 | 0.936015 | 0.0099 | Na | 0.025 | Na |
| Total | 547 | 512 | 0.936015 | 0.0099 | Na | 0.025 | Na |

## **Sucker** *Catostomus spp.*




Suckers were observed throughout Summit Creek but were most abundant in the lower regions of the creek. A 50% reduction was not achieved at all sample sites because it was not a requirement of the protocol. When making assumptions about population estimates only the sample units that achieved a 50% reduction should be used. Sample unit 16 was removed from the data set to be consistent with the established protocol (Dambacher 1997). There were 406 suckers sampled with the average probability of capture being 84% and a probability of non-capture of 16%. The estimated population of suckers in Summit Creek was 5567+/- 2472with a 95% confidence level (Table 29).

Table 29. Population Estimate for Sucker in Summit Creek 2001.

| Summit Creek | | Sucker | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Fish per square meter | | Fish per lineal meter | |
| Habitat type | Population estimate | +/- 95% c.l. | CL % of estimate | Habitat type | Reach average | Habitat type | Reach average |
| Mix | 5567 | 2472 | 0.444045 | 0.1012 | Na | 0.253 | Na |
| Total | 5567 | 2472 | 0.444045 | 0.1012 | Na | 0.253 | Na |

### Bull Trout

No bull trout were observed within the 32 sample sites of Summit Creek.

### Upper Limits

The upper limit of fish was found at UTM: Zone 11, 0379724 North and 4900391 West. This is very close to the location ODFW had previously determined (Bowers).

## Discussion

Salmonids were the focus of this population study. Rainbow trout were found throughout Summit Creek. Brook trout were found mainly in the upper reaches of Summit Creek. In the middle part of the survey, 0.5 kilometers was skipped because of several beaver ponds. In addition, another 1 kilometer was not surveyed due to no access to private land. There were no bull trout sampled in Summit Creek even though water qualities appeared to be habitable in the upper reaches.

The Summit Creek population estimate survey has provided some good base line information on what species are present in the system as well as where they reside spatially. This information will be beneficial for managers and landowners when making decisions that will possibly affect the landscape.

## References

Bowers, W. 2001. Personal communication with District Fish Biologist, Oregon Department of Fish and Wildlife, Hines, Oregon

Dambacher, J.M. 1997. Electrofishing Population Estimation Spreadsheet. Version 2.0

# Use of Radio Telemetry to Document Movements of Brook Trout in the Upper Malheur Basin in Oregon

AUTHOR: JASON FENTON, BURNS PAIUTE TRIBE FISH AND WILDLIFE DEPARTMENT, BURNS,OR

## Introduction

In 2000 and 2001, research was conducted on brook trout *Salvelinus fontinalis* in the Malheur River above Warm Springs Reservoir (referred to as the Upper Malheur River). Brook trout hybridize with bull trout *Salvenlinus confluentus* which are at risk of extinction (Markle 1992).

Brook trout were introduced into the Upper Malheur River in the 1930's in the high lakes of the Strawberry Mountains (Bowers et al. 1993). Brook trout compete with bull trout, which are considered threatened due to habitat degradation, downstream losses and hybridation. Brook trout are fall spawners similar to bull trout. Little is known exactly where the brook trout spawn in reference to the bull trout or the time of year peak spawning occurs for either species in the Upper Malheur River. The Burns Paiute Tribe (The Tribe) and partners developed the following objectives for brook trout:

1) Identify migratory movements of brook trout within the Upper Malheur basin.
2) Identify the timing and location of brook trout spawning in the Upper Malheur basin.
3) Collect information that can be used in the development and implementation of a brook trout eradication plan.

The study was done in conjunction with the Tribe's bull trout study since it would be minimal effort to include brook trout. The focus of the study area for the 2000 and 2001 field seasons stretched from Summit Creek to the headwaters of the Upper Malheur (Figures 6,7). This report will reflect research from 22 June 2000 to 21 November 2001.

Figure 6. Study area for brook trout migration study in 2000 and 2001.

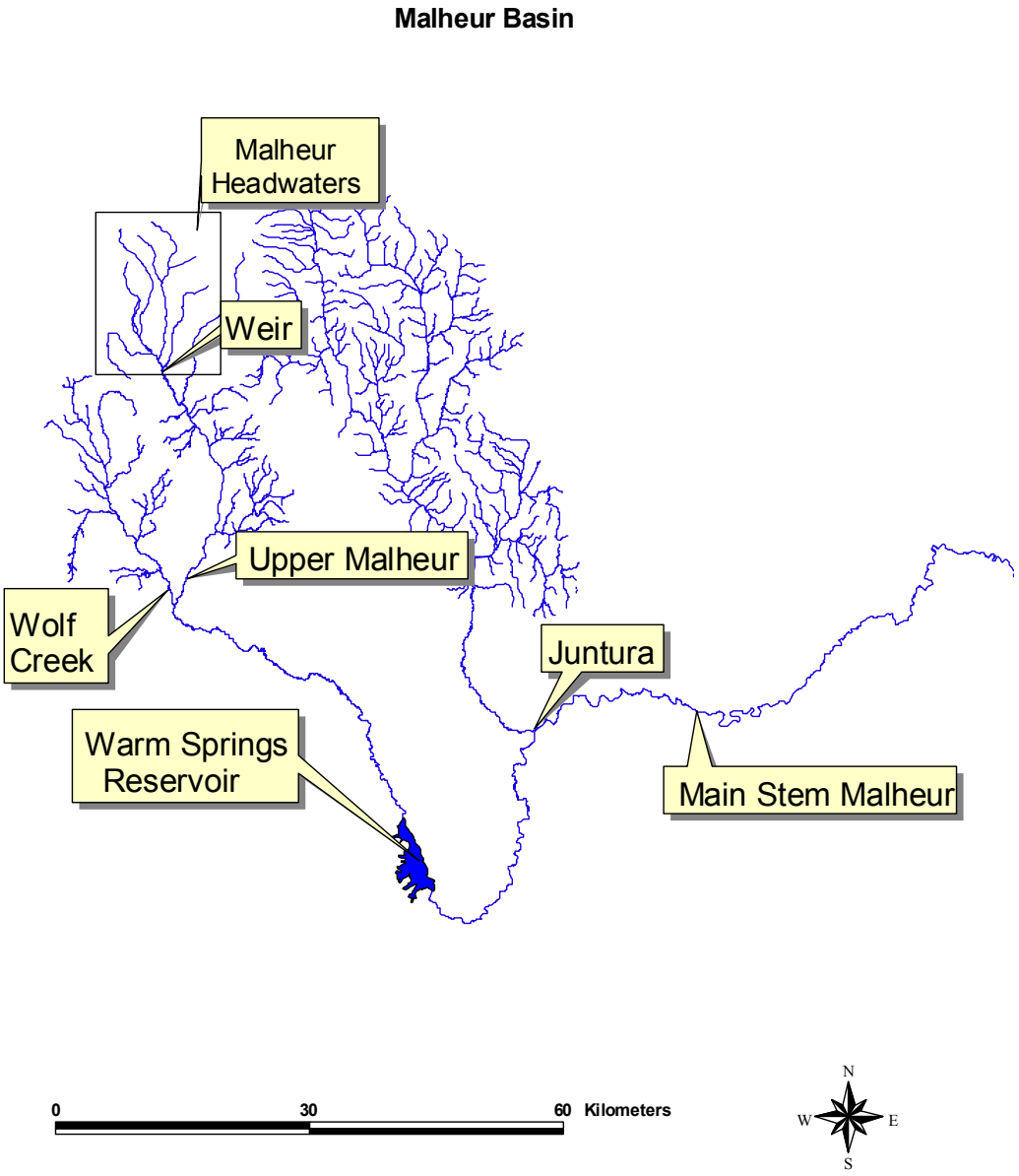
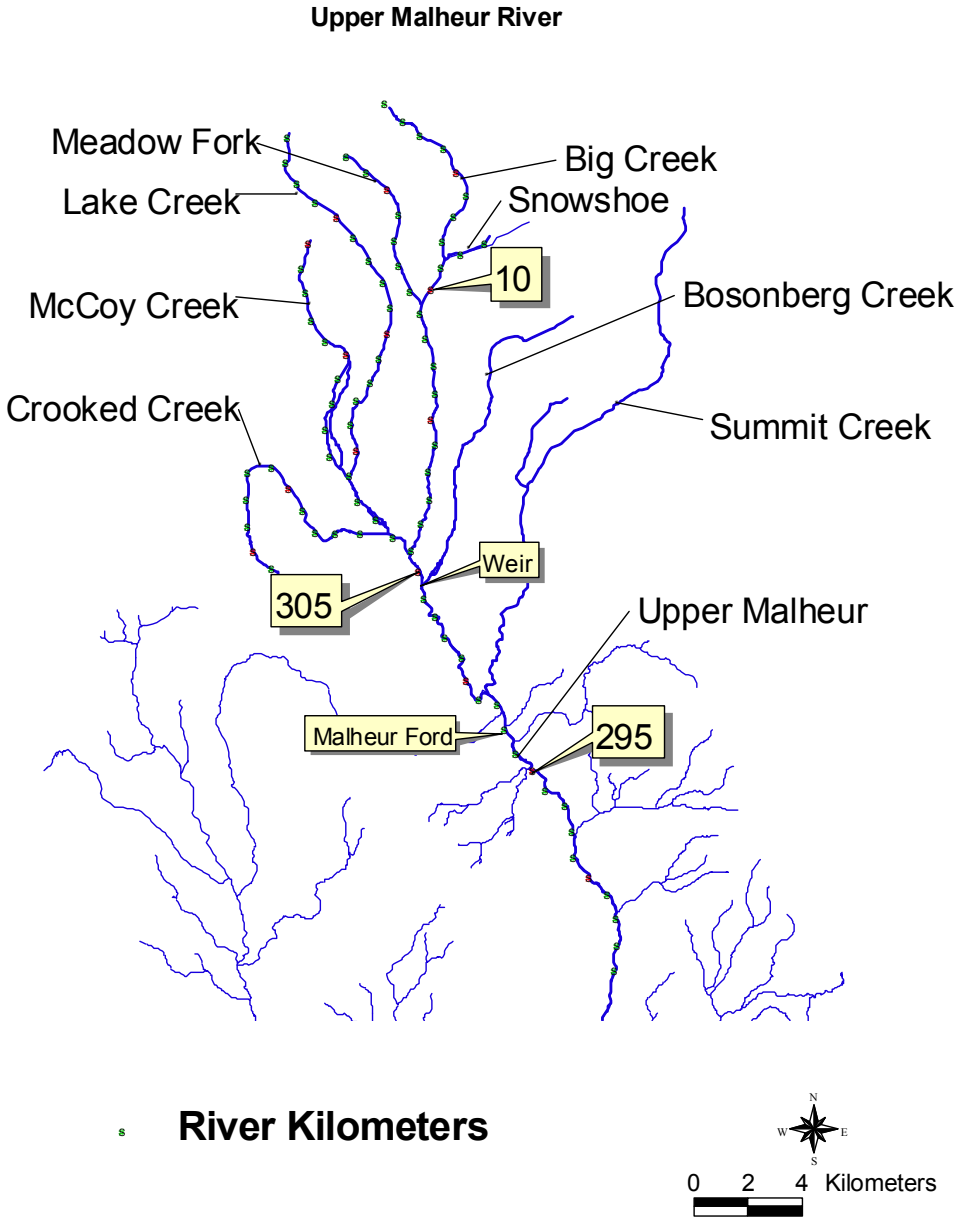


Figure 7. Study area for brook trout migration study in 2000 and 2001.



# Methods

## Fish Collection

Brook trout were collected from a weir that was installed for the corresponding bull trout study. The weir had been placed in the Upper Malheur River at River Kilometer (RK) 304. The weir spanned across the Upper Malheur River at a slight angle with a trap box on each side. It was constructed of 12-foot aluminum panels that had ½ diameter rod holes. The rods were spaced out ¼ inches apart. Fence posts were pounded into the streambed and wired to the weir for stabilization.

Angling with bait, lures and flies was conducted to collect additional brook trout. Those fish that were large enough for a transmitter were placed into a live trap for surgery.

## Radio Implantation

Radio transmitters that were manufactured by Advanced Telemetry Systems Inc. (ATS) had external whip antennas that emitted a unique frequency in either the 150 or 151 MHz band. Some of the radios used were salvaged from a bull trout study conducted in 1999 and 2000. The old radios had not previously been used. Two sizes of radios were used and were guaranteed when new for 140 days (3.6 grams) and 90 days (8 grams).

Captured brook trout were anesthetized with seltzer water, measured (fork length in mm) and weighed (g). Radio transmitters were inserted internally through a midline internal incision (Ross and Kleiner 1982). The external whip antennas were threaded through the body cavity and exited behind the pelvic fin. During the surgery the gills were bathed with seltzer water. Synthetic absorbable surgical sutures and super glue were used to seal the incision. After the surgery, the fish were held in fresh water until equilibrium was recovered, then released back into the river. Fish aerators were used in all holding buckets to provide increased oxygen levels.

## Radio Telemetry

The tracking of radio tagged brook trout was conducted on average four times a week to obtain the approximate location of each fish. An ATS receiver, Yagi antenna, and a 12 channel hand-held GPS unit were used to locate fish. Foot travel and vehicle were the primary methods used to locate individual fish. A fixed wing aircraft was used to locate radio signals on roadless or private areas. Visual identification was preferred but rarely happened. The frequency of each fish, time located, and UTM location were recorded for all positive locations.

# Results

## Brook Trout 2000

Angling methods collected two brook trout large enough for a radio tag implant. Both of these fish were caught and released five miles above the weir. The first brook trout that was a candidate for a radio was caught on 22 June 2000. Over the next six weeks, nine more brook trout were implanted with radios, the last one on 28 July 2000 (Table 30). The majority of the brook trout were collected at the weir trap. The fork length (mm) of the brook trout collected ranged from 30 – 298 mm (mean = 161). A total of 78 brook trout were caught from 1 June 2000 to 23 October 2000 at the trap site: 39 in the upstream trapbox and 39 in the downstream trapbox. At least one brook trout was sampled 18 of the 22 weeks the trap operated (Figure 8).

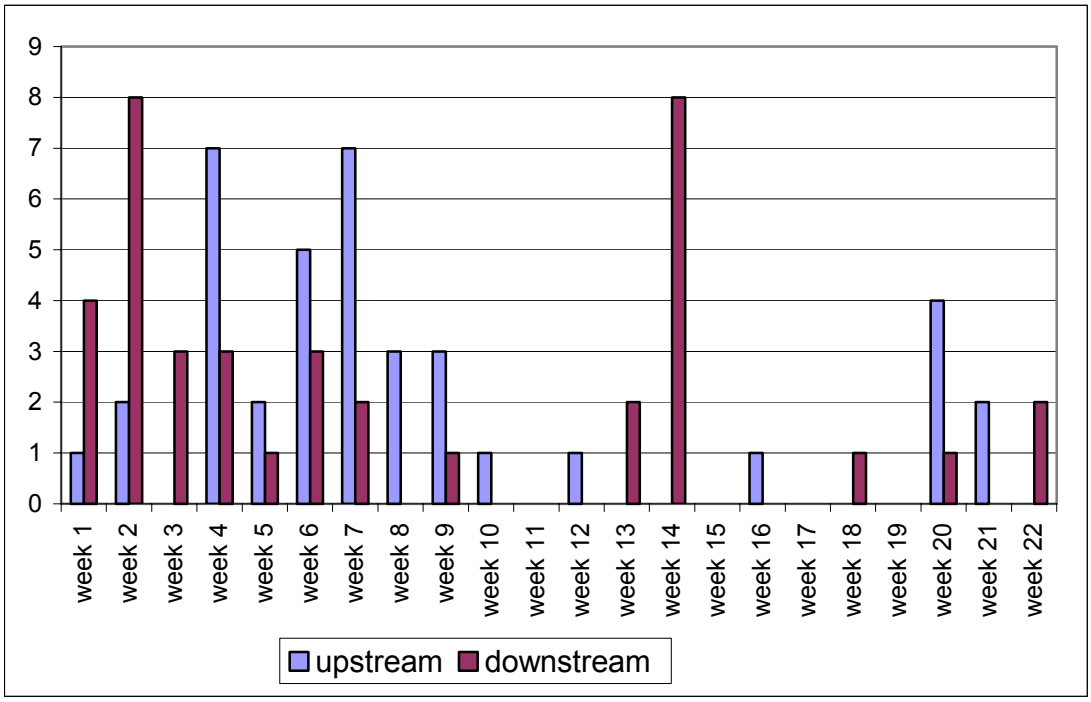



Figure 8. Number of brook trout caught in the weir trap in 2000. Week 1 and 22 are not full weeks due to trap installation and trap disassembling.

Table 30. Brook trout that were radio tagged in 2000.

| Date of Implant | Radio Frequency | Radio Size (g) |
|---|---|---|
| 6/22/00 | 151.533 | 8.0 |
| 6/29/00 | 151.523 | 3.6 |
| 7/15/00 | 150.722 | 3.6 |
| 7/15/00 | 150.862 | 3.6 |
| 7/15/00 | 150.951 | 3.6 |
| 7/17/00 | 151.012 | 3.6 |
| 7/18/00 | 151.022 | 3.6 |
| 7/24/00 | 151.593 | 8.0 |
| 7/25/00 | 150.803 | 3.6 |
| 7/28/00 | 151.032 | 3.6 |

A total of 48 telemetry observations were documented between 6-22-00 and 11-27-00 (Table 31). Most of the tracking was done by foot or truck. The US Forest Service and the Tribe conducted an aerial tracking flight by fixed wing aircraft on 8-11-00.

Table 31. Radio telemetry observations for brook trout in 2000.

| Foot Observations | Vehicle Observations | Plane Observations | Total Observations |
|---|---|---|---|
| 30 | 10 | 8 | 48 |

## Brook Trout Movement 2000

No radio tagged fish were recaptured in the trap. Two of the ten brook trout were never located again after their surgery. The highest any brook trout was located upstream of the weir was on 7 September 2000 near Big Creek Campground (RK 311).

One brook trout (150.803) did not survive the day after the surgery and was found at the weir site. Two brook trout (151.022,150.722) were never located after the surgery. The rest are as follows:

150.862 tracked to the confluence of Big and Lake Creek then was not located again

150.523 tracked to Big Creek and located just above the 16rd. This fish did not leave the area.

150.951 found expelled radio just below Lake and Big Creek (highest point this radio tag traveled)

151.012 this brook trout was not located for four months and was then tracked to Lake Creek on private land above Logan Valley (RK 312). This fish was not pinpointed due to the lack of public access. It is not known if the fish was brought here by a predator. The radio appeared to be out of the water.

151.593 this brook trout was not located for three months after surgery. It was then located on private land near Bosonberg Creek. This fish was not pinpointed due to the lack of public access. It is not known if the fish was brought there by a predator. The radio appeared to be out of the water.

151.533 this brook trout was tracked to the confluence of Lake and Big Creek then was found 6 kilometers away under a large snag, one kilometer from the nearest water.

151.032 this brook trout was tracked once near Big Creek Campground then was not located until two months later near the town of Drewsey.

No radio tagged brook trout were found on a redd in 2000.

## Brook Trout 2001

Angling methods did not collect any brook trout. The first brook trout caught in the weir that was large enough for a radio tag was on 9 June 2001. Over the next five weeks three more brook trout were implanted with radio tags, the last one on 7-17-2001 (Table 32).

The weir trap collected a total of 34 brook trout between 21 May and 25 October 2001, 28 in the upstream trap box and 6 in the downstream trap box (Figure 9). The fork length of brook trout ranged from 92 – 287mm (mean 201).

Table 32. Brook trout that were radio tagged in 2001.

| Date of Implant | Radio Frequency | Radio Size (g) |
|---|---|---|
| 6/09/01 | 150.584 | 8 |
| 7/11/01 | 150.723 | 8 |
| 7/11/01 | 151.862 | 8 |
| 7/17/01 | 151.036 | 11 |

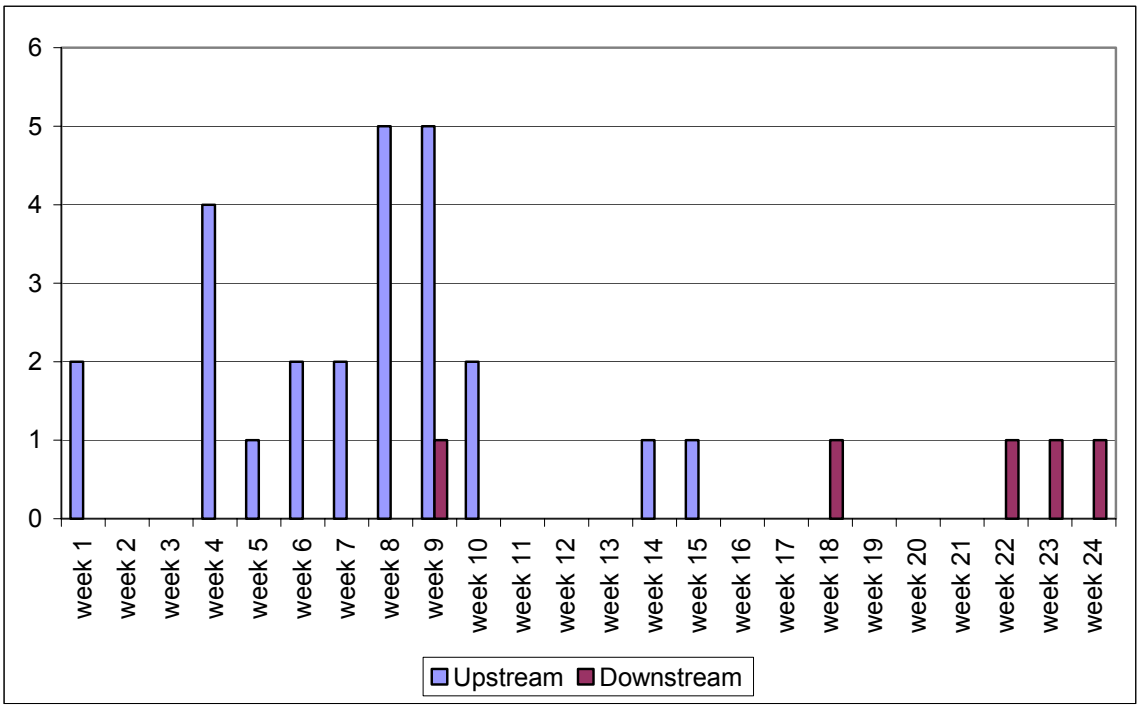



Figure 9. Number of brook trout caught in the weir trap in 2001. Week 1 and 24 are not full weeks due to trap installation and trap disassembling.

A total of 39 telemetry observations were documented between 6-20-01 and 11-21-01 (Table 33). All of the telemetry tracking was done by foot or truck.

Table 33. Radio telemetry observations for brook trout in 2001.

| Foot Observations | Vehicle Observations | Plane Observations | Total Observations |
|---|---|---|---|
| 22 | 17 | 0 | 39 |

## Brook Trout Movement 2001

All the brook trout were released above the weir and no radio tagged fish were recaptured in the trap. The highest any brook trout was located upstream of the weir was on 30 September 2001 near Big Creek Campground (RK 311).
The four brook trout that were radio tagged in this study all migrated 6 km above the weir. Three of the brook trout were in Big Creek 6 km above the weir. The fourth brook trout went to Bosonberg Creek 6 km above the weir.

150.584 this brook trout moved up 6 km above the weir and continued to stay in the area.

150.723 this brook trout moved up into Bosonberg Creek until it was 6 km above the Weir. This fish stayed in the area until 30 September then migrated downstream until it was below the weir 6 km in the Upper Malheur River.

151.862 this brook trout moved up 6 km above the weir to Big Creek then did not move from the area.

151.036 signal was lost for 2 ½ months after the radio tag was implanted. On 30 September the signal was found 6 km above the weir in Big Creek. This brook trout stayed in this area until 26 October when the signal was found near Bosonberg on private land.

No brook trout were found on a redd in 2001.

## Discussion

The radio tags used for the brook trout studies in 2000 and 2001 were unused radios from the previous years bull trout study. These radios are guaranteed to last a certain number of days when new. Even when the radios are not used during the season they tend to lose some battery power. The radios that were implanted into the brook trout did not seem to function properly and this is most likely the result of weak batteries.

The tracking effort for radio tagged brook trout was less intensive compared to past bull trout efforts in the subbasin. This objective lies outside the scope of the project, but members of the Malheur River Bull Trout Recovery Unit Team agreed that migratory data on brook trout would provide local land and fish managers critical information in determining future management decisions in the recovery of bull trout with the presence of an exotic species. Tracking effort targeted bull trout. Since both species tend to encompass the same study area, the telemetry data for brook trout was documented with very little additional effort.

During the 2000 and 2001 field seasons, brook trout were observed migrating upstream from the weir after receiving a radio implant. Nine of the 15 radio tagged brook trout provided fair migration data. The maximum migration upstream observed was 6 kilometers: one radio tagged brook trout was observed in Lake Creek on private land just above the FS 16 road; 6 in Big Creek from RK 3 to 6 (all observation located below Big Creek Campground), and 2 in Bosenburg Creek from RK 4 to 6. Brook trout migration into headwater tributaries of the Malheur River is more diverse than that exhibited by bull trout *Salvelinus confluentus.* Furthermore, general upstream migration distances for brook trout is less than bull trout (see annual report 2000 pp 11-32: annual report 2001 pp 38-65).

The data that was collected in this study seems to suggest that brook trout are migrating from below RK 304 in May through July. The brook trout seemed to prefer Big Creek although there was one that went to Lake Creek and two that migrated into Bosonberg Creek.

Downstream migration behavior for brook trout tends to be minimal. The relatively small sample size provides very limited data, especially late in the season when radio tags tend to expire. Migration into Logan Valley below the 16 road is evident in October, but most of the radio tagged brook trout resided in the tributaries that they initially migrated into. Only two fish were observed downstream of the weir trap site by November: one fish from 2000 and one from 2001. The lowermost observation was noted on 27 November 2000 at RK 241, just upstream of the town of Drewsey, OR. Surveyors assumed this fish to be on a hill side but due to no access to private land it could not be confirmed. This fish was last observed near Big Creek campground on 7 September 2000. The location of this fish is suspicious and may have been taken by an angler. The other radio tagged brook trout observed below the weir was determined to be alive. This fish was located at river kilometer 297 on 21 November 2001, 8 miles below the weir site.

Though distribution of brook trout in tributaries downstream of Summit Creek is unknown, the presence of brook trout in the mainstem Malheur River with some permanent migration barriers downstream to Warm Springs Reservoir pose a risk to native resident fish if brook trout migrate and establish populations in some of these tributaries. From the data collected in 2000 and 2001, distribution of brook trout are limited to the extreme Upper Malheur River basin (approximately RK 297 to headwaters).

No radio tagged brook trout in 2000 or 2001 were observed on redds. Previous spawning surveys have documented redds in the area of Big Creek where the majority of the radio tagged brook trout were observed. It is unknown if any of the radio tagged brook trout spawned.

Predation on the radio tagged brook trout seemed to be minimal. In 2000, one brook trout was tracked near Big Creek Campground then was lost. Two months later the signal was picked up near the town of Drewsey, 52 km southeast. The observed location was not near any water sources suggesting this fish was taken by an angler or a predator. The radio was on private land so it was not pinpointed. Two other brook trout seemed to be taken by birds. One of these radio tags was recovered under a large snag, one kilometer from the nearest water. The other fish seemed to move from Big Creek to Bosonberg Creek in one day, about a 12 km trip. This radio was not recovered due to private land. No brook trout appeared to be taken by predators in 2001.

# References

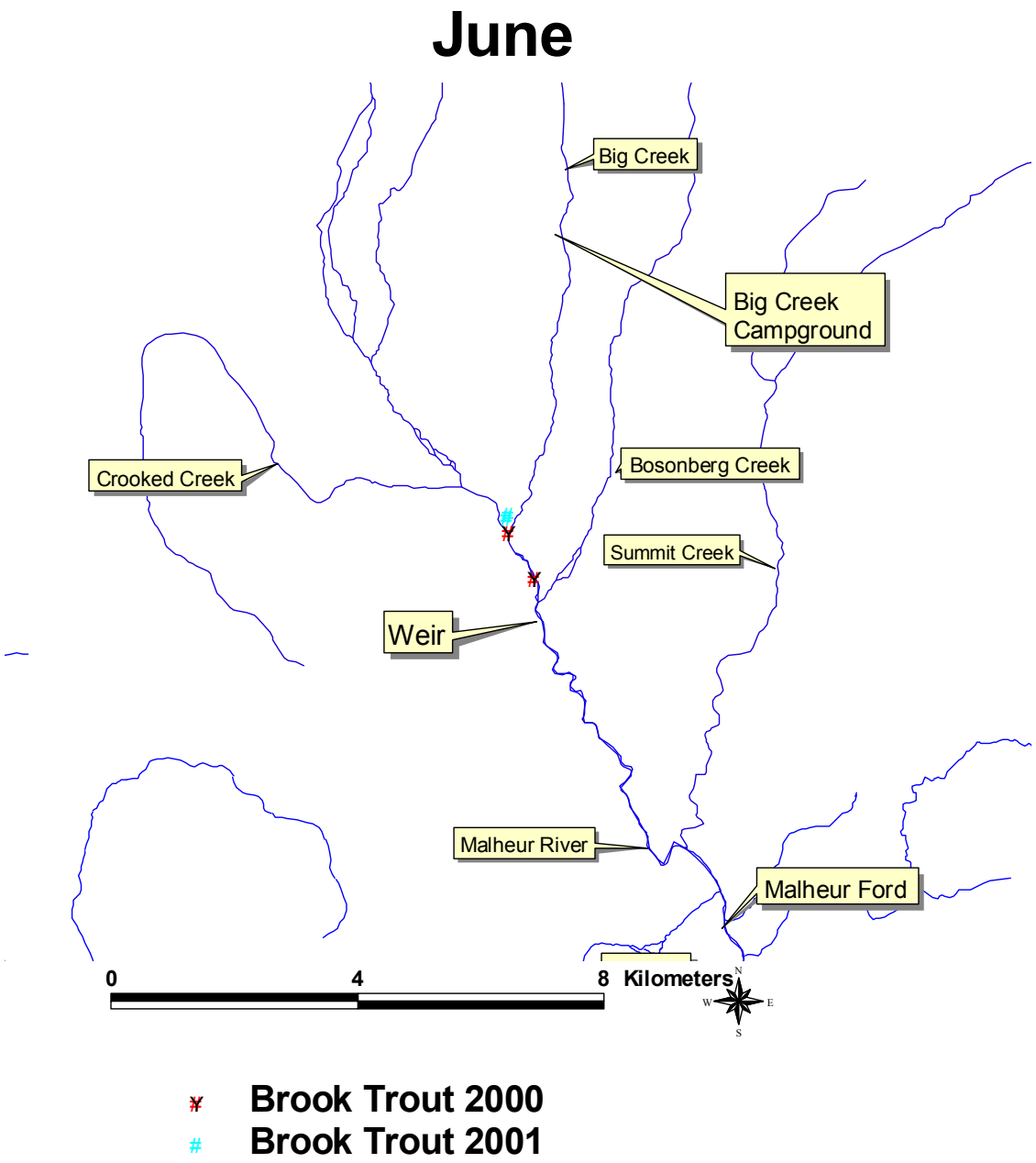
Bowers, W.L., P.A. Dupee, M.L. Hanson, and R.R. Perkins. 1993 Bull Trout Populations Summary Malheur River Basin. Oregon Department of Fish and Wildlife, Hines, Oregon. Unpublished report.

Markle, D.F. 1992. Evidence of bull trout x brook trout hybrids in Oregon. In: Howell, P.J.; Buchanan, D.V. eds. Proceedings of the Gearheart Mountain bull trout workshop. Corvallis, OR; Oregon Chapter of the American Fisheries Society: 58-67.

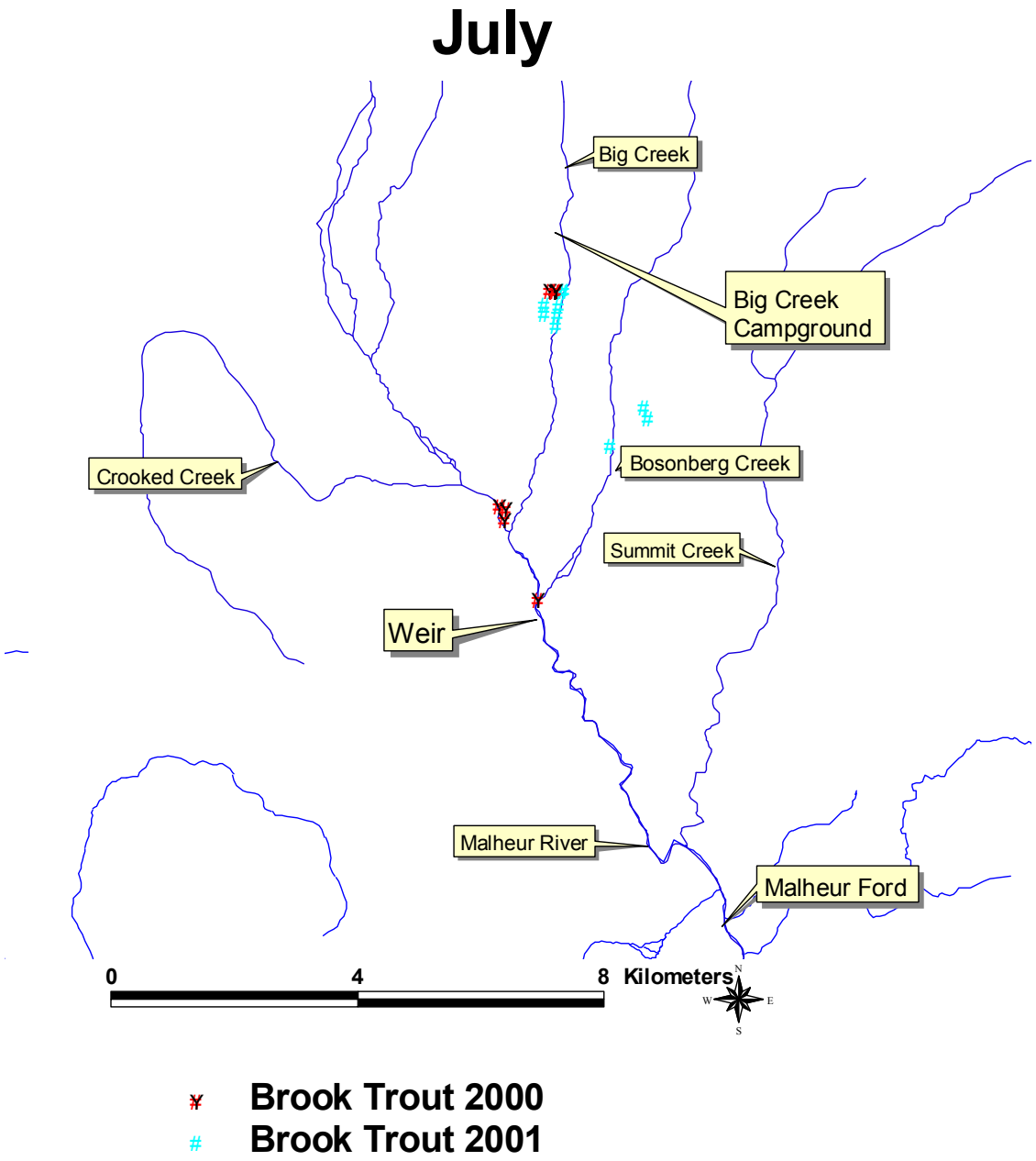
Ross, M.J. and C.F. Kleiner. 1982. Shielded – needle techniques for surgically implanting radio – frequency transmitters in fish. Progressive Fish – Culturist 44 (1): 41-43.

**Appendix H. Monthly observations of brook trout in the Upper Malheur River, 2000 and 2001.**

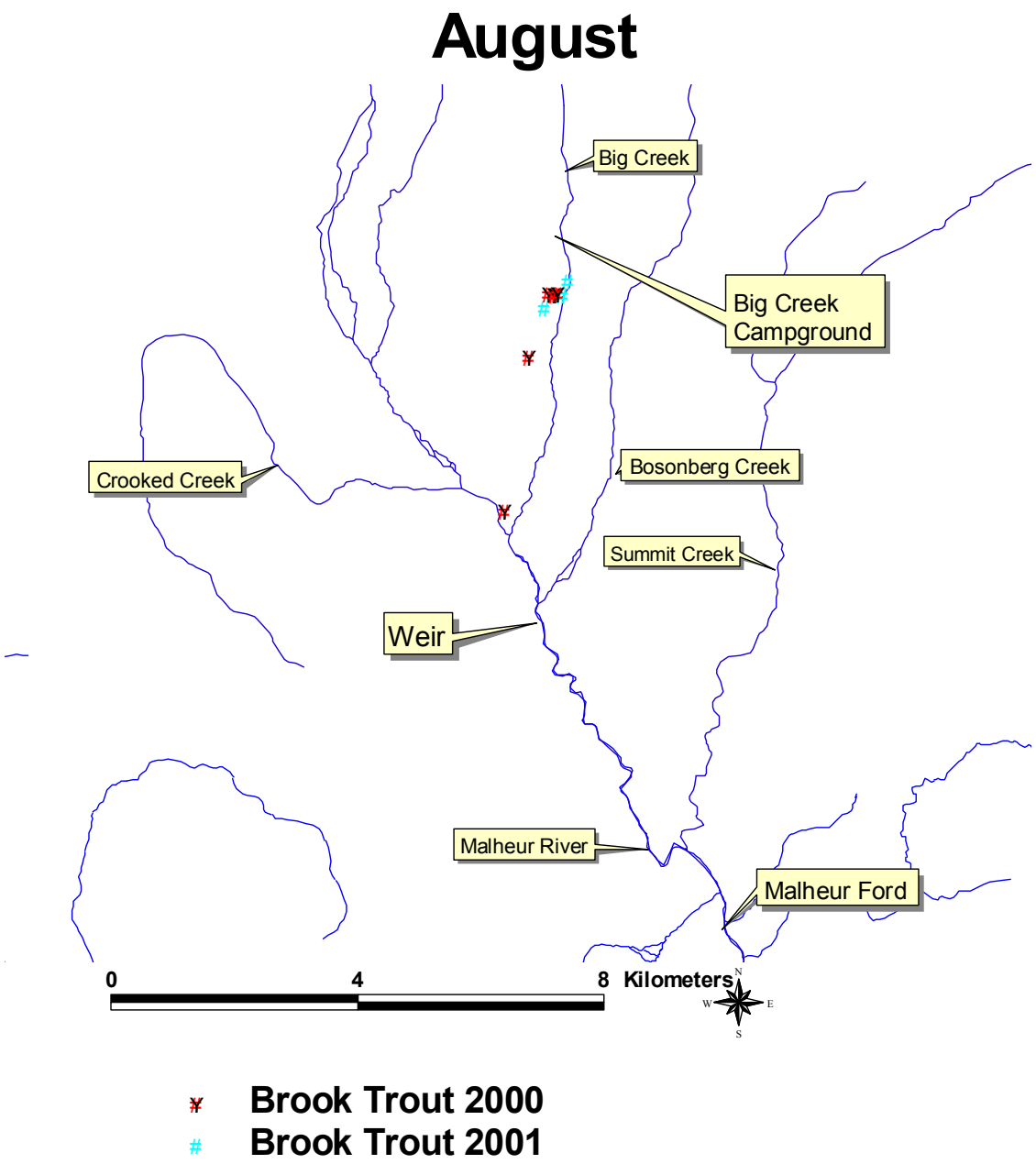
**Appendix H-1. Monthly observations of brook trout in the Upper Malheur River, 2000 and 2001.**



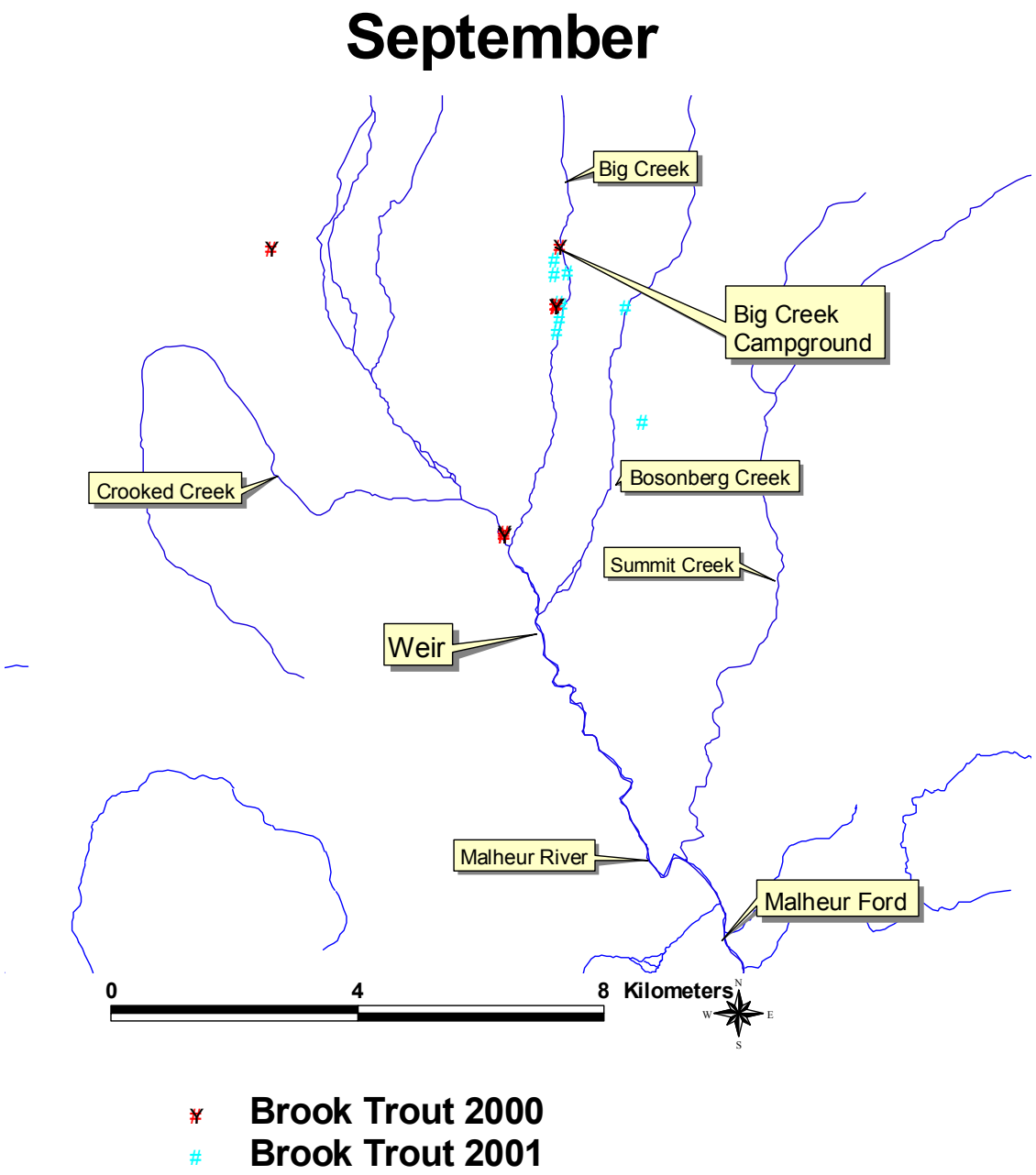
**Appendix H-2. Monthly observations of brook trout in the Upper Malheur River, 2000 and 2001.**



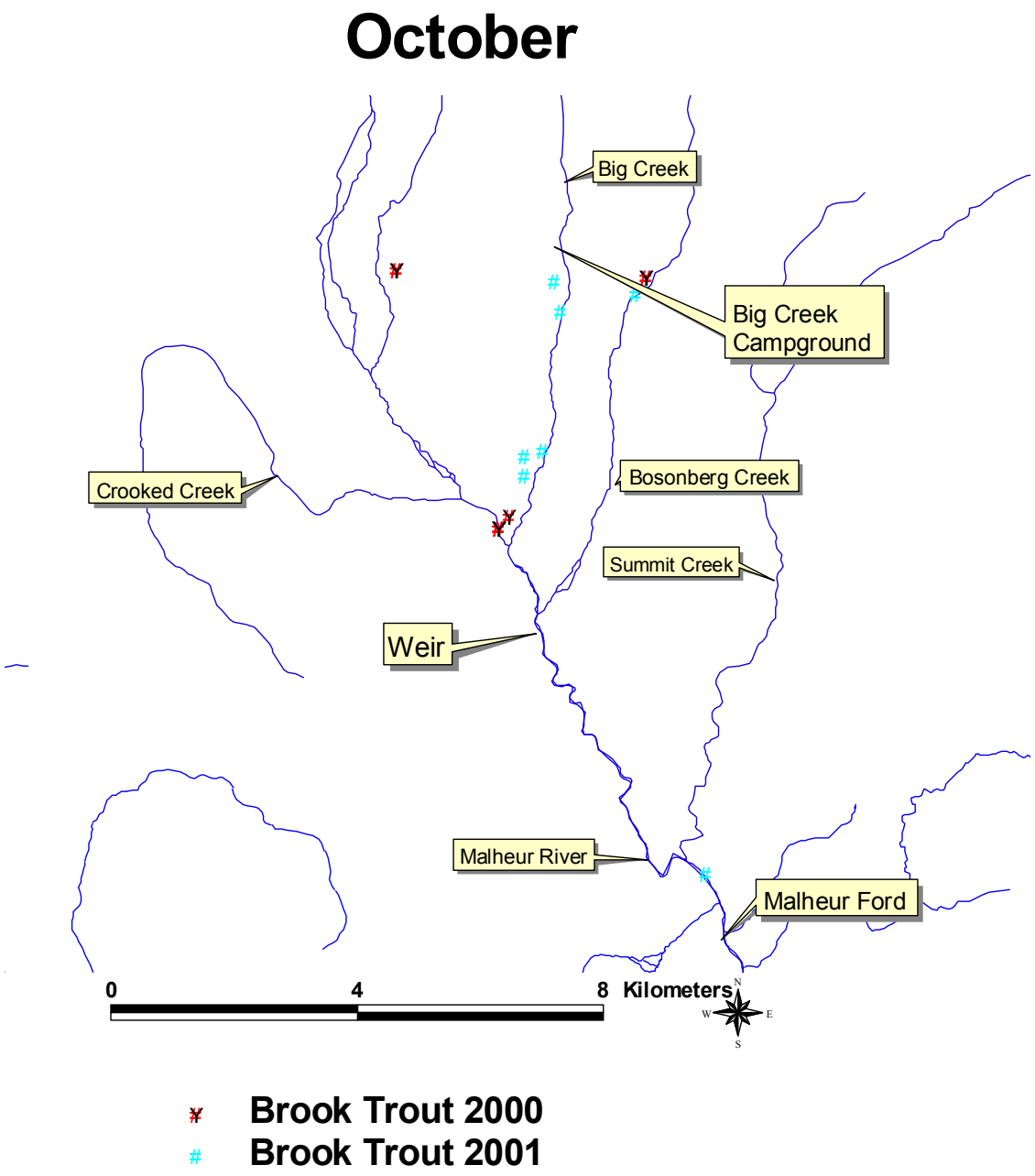
**Appendix H-3. Monthly observations of brook trout in the Upper Malheur River, 2000 and 2001.**



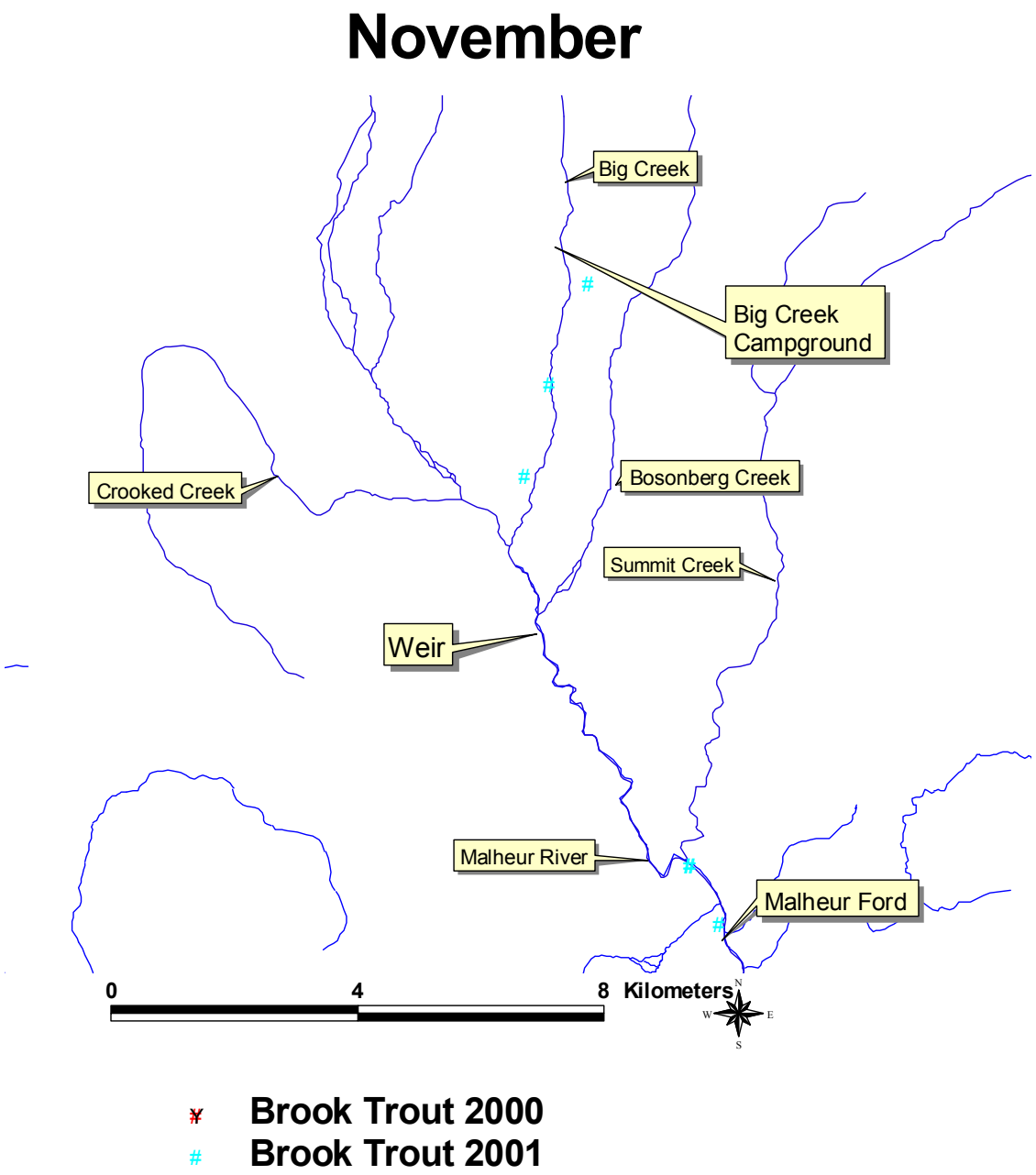
**Appendix H-4. Monthly observations of brook trout in the Upper Malheur River, 2000 and 2001.**



**Appendix H-5. Monthly observations of brook trout in the Upper Malheur River, 2000 and 2001.**



**Appendix H-6. Monthly observations of brook trout in the Upper Malheur River, 2000 and 2001.**



# Stream temperature monitoring on streams flowing through the Logan Valley wildlife mitigation property

# 2001

AUTHOR: LAWRENCE SCHWABE, BURNS PAIUTE TRIBE FISH AND WILDLIFE DEPARTMENT, BURNS, OR

## Introduction

The Burns Paiute Tribe, United States Forest Service, United States Bureau of Land Management, and Oregon Department of Fish and Wildlife have coordinated efforts and have maintained stream temperature sites in the Upper Malheur River. The information collected provides land and fish management agencies stream temperature trend data.

The Burns Paiute Tribe acquired the Logan Valley Oxbow Ranch in April 2000. The land purchase was funded by the Bonneville Power Administration and is intended to benefit fish and wildlife resources. The restoration of stream channel morphology and natural function is one of the primary goals stated in the Logan Valley Wildlife Mitigation Plan (Wenick et al. 2002).

The lower reaches of Big and Lake Creeks flow through the deeded land. These drainages support a local population of threatened bull trout *Salvelinus confluentus*. The current status of this population of bull trout is at a "high risk of extinction" (Buchanan et al. 1997).

Changes in the composition, vigor, and density of riparian vegetation produce corresponding changes in water temperature (Rosgen 1996). The goals outlined in the Logan Valley Management Plan will encourage the restoration of native riparian vegetation, stream channel morphology, and will be managed for fish and wildlife populations native to the site and surrounding areas. In 2000, stream temperature sites on the property were established. These sites will be used to monitor the trends of stream temperatures that are associated with the management of Logan Valley.

## Methods

The Burns Paiute Tribe, Oregon Department of Fish and Wildlife, BLM and US Forest Service have coordinated the effort to strategically place thermographs throughout the Malheur River Subbasin. Five temperature sites on the Logan Valley property have been monitored since 2000 (Table 34) (Figure 10). The stream temperature data collected on the Logan Valley property provides the Burns Paiute Tribe Fish and Wildlife Department trend and monitoring data that will assist the Tribe in the management of the deeded land.

The most commonly used technique for gathering water temperature is the use of continuous data recorders. StowAway and hobo XT data loggers manufactured by

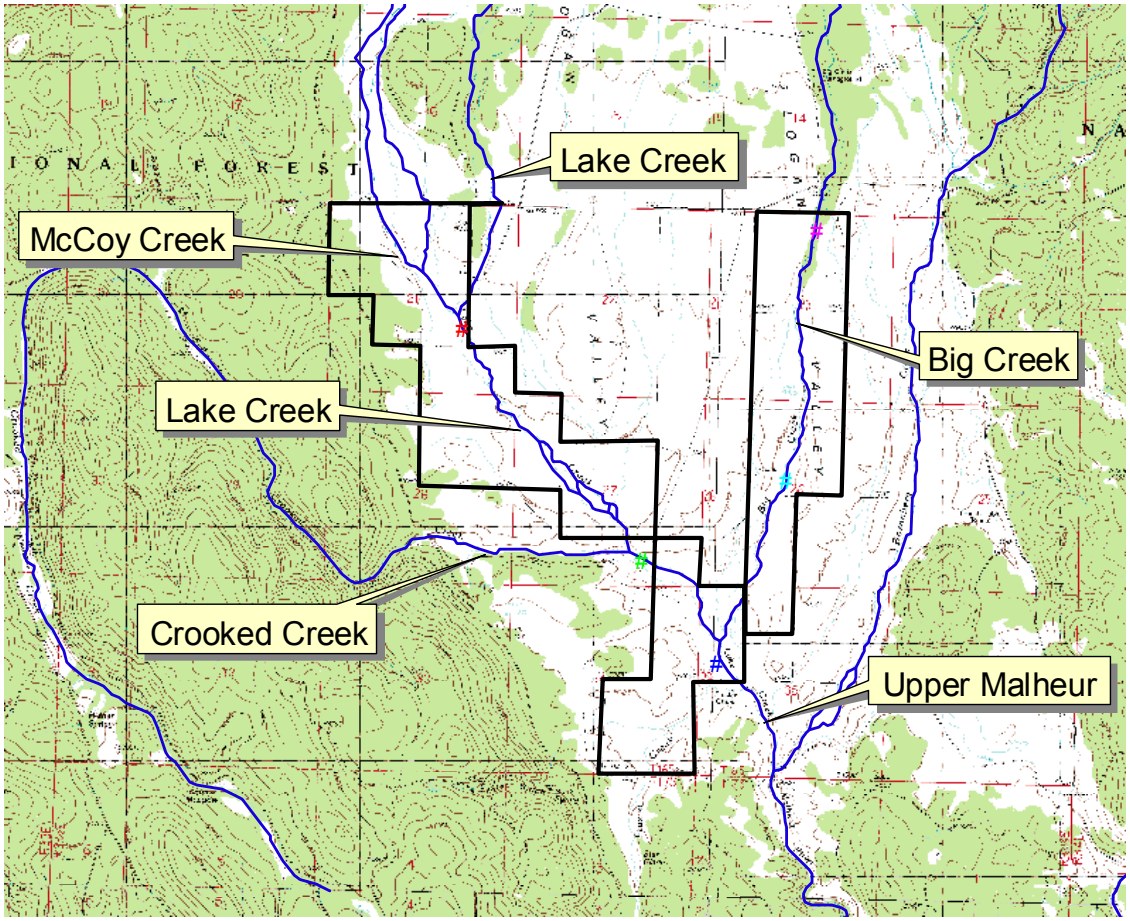
Onsett, Inc. were used at stream temperature monitoring sites. Data loggers were calibrated for accuracy using methods recommended by Oregon's Water Quality Monitoring Guide Book.

Temperature data will be analyzed based on rolling daily maximum temperatures averaged over a seven day period that is referred to as a Maximum Weekly Average Temperature (MWAT).

Table 34. Names of the five stream temperature sites that have been maintained since 2000.

| Site Number | Location |
|---|---|
| 1 | Lake Creek below McCoy Creek |
| 2 | Lake Creek below Crooked Creek |
| 3 | Malheur River below Lake and Big Creek |
| 4 | Big Creek approximately one mile below the 16 road |
| 5 | Big Creek below the 16 road |

Figure 10. Locations of Temperature Probes in Logan Valley.



# Results

## 2000 Stream Temperature Data

In 2000, all five stream temperature sites were activated with a 100% success rate of retrieving data. The data from the stream temperature probes were downloaded into Microsoft Excel. Table 1 displays the maximum temperature characteristics that occurred and associated time periods.

Table 35. Maximum temperatures and MWATs that occurred at the stream temperature monitoring sites in 2000.

| Site | Maximum Temperature (°C) | Date Maximum Temperature Occurred | MWAT (°C) | Week MWAT Occurred |
|---|---|---|---|---|
| **Site 1** (Upper Lake Cr.) | 26.65 | 8/01/00 | 25.55 | 7/27/00 to 8/02/00 |
| **Site 2** (Lower Lake Cr.) | 27.46 | 8/01/00 | 26.22 | 7/27/00 to 8/02/00 |
| **Site 3** (Malheur River Site) | 23.25 | 7/29/00 | 22.25 | 7/27/00 to 8/02/00 |
| **Site 4** (Lower Big Cr.) | 21.47 | 7/29/00 | 20.5 | 7/27/00 to 8/02/00 |
| **Site 5** (Upper Big Cr.) | 18.64 | 8/01/00 | 18.0 | 7/27/00 to 8/02/00 |

From the data collected from the 5 stream temperature monitoring sites, maximum stream temperatures were recorded on 8/1/00 at sites 1,2, and 5 while sites 3 and 4 recorded maximum temperatures on 7/29/00. The MWAT was in agreement for all sites. See appendix 1 for stream temperature data collected in 2000.

## 2001 Stream Temperature Data

In 2001, 4 stream temperature sites were activated with an 80% success rate of retrieving data. The stream temperature probe at site #2 was on Onset Hobo Temp that malfunctioned due to a poor seal. The data from the stream temperature probes were downloaded into Microsoft Excel. Table 1 displays the maximum temperature characteristics that occurred and associated time periods.

Table 36. Maximum temperatures and MWATs that occurred at the stream temperature monitoring sites in 2001.

| Site | Maximum Temperature (°C) | Date Maximum Temperature Occurred | MWAT (°C) | Week MWAT Occurred |
|---|---|---|---|---|
| **Site 1** (Upper Lake Cr.) | 27.18 | 8/07/01 | 25.36 | 6/30/01 to 7/06/01 |
| **Site 2** (Lower Lake Cr.) | NA | NA | NA | NA |
| **Site 3** (Malheur River Site) | 24.2 | 7/04/01 | 22.37 | 7/01/01 to 7/07/01 |
| **Site 4** (Lower Big Cr.) | 22.63 | 7/04/01 | 21.13 | 7/01/01 to 7/07/01 |
| **Site 5** (Upper Big Cr.) | 18.63 | 7/04/01 | 17.12 | 6/30/01 to 7/06/01 |

From the data collected from the 4 stream temperature monitoring sites, maximum stream temperatures were recorded on 8/7/01 at sites 1 and on 7/4/01 at sites 3, 4, and 5. The MWAT was occurred 1 day earlier for sites 1 and 5.

## Discussion

Two years of data provide very little insight into the effects of the management of Logan Valley. As riparian and channel conditions improve, it is expected that aquatic habitat, stream temperatures and flows will change. The established monitoring sites will provide the Tribe trend data in respect to stream temperatures. The following list is recommended monitoring activities that need to be conducted concurrently with the stream temperature monitoring to adequately measure aquatic habitat trends on the Logan Valley Mitigation property:

- Establish and maintain stream channel cross section sites that will monitor channel condition over time.
- Establish and maintain stream discharge sites to monitor flow changes over time.
- Continue monitoring stream temperature sites on Logan Valley.
- Design, plan, and implement an aquatic monitoring inventory that will assess fish distribution and change over time.

# References

Buchanan, D.V., M.L. Hanson, and R.M. Hooton. 1997. Status of Oregon's bull trout. Oregon Department of Fish and Wildlife. Portland, Oregon.

Rosgen, Dave. 1996. Applied River Morphology. Wildland Hydrology. Pagosa Springs, Colorado.

Wenick, J., Gonzalez, D., A. First Raised, and B. Coahran. 2002. Draft Logan Valley Wildlife Mitigation Plan. Burns Paiute Tribe. Burns, Oregon.

## Appendix I. Temperature readings from probe located at Lake Creek below McCoy Creek, 2000.

**Site: Lake Creek below McCoy Creek**
**Date deployed:6/23/00**
**Date retreived: 9/18/00**
**Maximum temperature of 26.65 occurred on 8/1/00**
**MWAT of 25.55 occurred on 7/27/00 to 8/2/00**

**Max of Temperature (*C)**

| Date Time | Max | MWAT | Min | Avg |
|---|---|---|---|---|
| 6/24/00 | 21.51 | | 7.76 | 14.64 |
| 6/25/00 | 22.67 | | 8.53 | 15.60 |
| 6/26/00 | 22.17 | | 8.22 | 15.20 |
| 6/27/00 | 22.67 | | 7.76 | 15.22 |
| 6/28/00 | 23.18 | | 8.99 | 16.09 |
| 6/29/00 | 23.87 | | 9.61 | 16.74 |
| 6/30/00 | 23.52 | 22.80 | 10.39 | 16.96 |
| 7/01/00 | 20.36 | 22.63 | 10.86 | 15.61 |
| 7/02/00 | 21.67 | 22.49 | 8.37 | 15.02 |
| 7/03/00 | 19.71 | 22.14 | 8.68 | 14.20 |
| 7/04/00 | 17.28 | 21.37 | 6.36 | 11.82 |
| 7/05/00 | 14.11 | 20.07 | 7.91 | 11.01 |
| 7/06/00 | 19.06 | 19.39 | 8.37 | 13.72 |
| 7/07/00 | 20.19 | 18.91 | 8.06 | 14.13 |
| 7/08/00 | 18.24 | 18.61 | 9.77 | 14.01 |
| 7/09/00 | 20.68 | 18.47 | 8.06 | 14.37 |
| 7/10/00 | 23.01 | 18.94 | 8.06 | 15.54 |
| 7/11/00 | 22.51 | 19.69 | 8.68 | 15.60 |
| 7/12/00 | 23.52 | 21.03 | 10.71 | 17.12 |
| 7/13/00 | 24.04 | 21.74 | 10.24 | 17.14 |
| 7/14/00 | 24.04 | 22.29 | 10.24 | 17.14 |
| 7/15/00 | 23.01 | 22.97 | 10.86 | 16.94 |
| 7/16/00 | 18.73 | 22.69 | 9.46 | 14.10 |
| 7/17/00 | 19.06 | 22.13 | 11.01 | 15.04 |
| 7/18/00 | 19.87 | 21.75 | 11.32 | 15.60 |
| 7/19/00 | 23.36 | 21.73 | 9.93 | 16.65 |
| 7/20/00 | 25.25 | 21.90 | 10.71 | 17.98 |
| 7/21/00 | 24.39 | 21.95 | 11.01 | 17.70 |
| 7/22/00 | 24.73 | 22.20 | 11.94 | 18.34 |
| 7/23/00 | 22.51 | 22.74 | 10.86 | 16.69 |
| 7/24/00 | 24.73 | 23.55 | 9.61 | 17.17 |
| 7/25/00 | 24.73 | 24.24 | 10.71 | 17.72 |
| 7/26/00 | 24.39 | 24.39 | 11.17 | 17.78 |
| 7/27/00 | 25.08 | 24.37 | 11.32 | 18.20 |
| 7/28/00 | 25.25 | 24.49 | 11.32 | 18.29 |
| 7/29/00 | 26.29 | 24.71 | 12.72 | 19.51 |
| 7/30/00 | 24.04 | 24.93 | 13.96 | 19.00 |
| 7/31/00 | 25.94 | 25.10 | 13.96 | 19.95 |
| 8/01/00 | 26.65 | 25.38 | 14.11 | 20.38 |
| 8/02/00 | 25.6 | 25.55 | 11.79 | 18.70 |
| 8/03/00 | 23.7 | 25.35 | 11.63 | 17.67 |
| 8/04/00 | 23.7 | 25.13 | 13.34 | 18.52 |

**Max of Temperature (*C)**

| Date Time | Max | MWAT | Min | Avg |
|---|---|---|---|---|
| 8/05/00 | 24.73 | 24.91 | 11.32 | 18.03 |
| 8/06/00 | 23.52 | 24.83 | 10.86 | 17.19 |
| 8/07/00 | 24.22 | 24.59 | 10.86 | 17.54 |
| 8/08/00 | 24.39 | 24.27 | 10.24 | 17.32 |
| 8/09/00 | 23.87 | 24.02 | 11.17 | 17.52 |
| 8/10/00 | 23.36 | 23.97 | 11.48 | 17.42 |
| 8/11/00 | 23.36 | 23.92 | 10.39 | 16.88 |
| 8/12/00 | 23.7 | 23.77 | 9.77 | 16.74 |
| 8/13/00 | 22.67 | 23.65 | 9.77 | 16.22 |
| 8/14/00 | 22.84 | 23.46 | 8.68 | 15.76 |
| 8/15/00 | 22.34 | 23.16 | 8.83 | 15.59 |
| 8/16/00 | 22.67 | 22.99 | 7.91 | 15.29 |
| 8/17/00 | 22.84 | 22.92 | 8.68 | 15.76 |
| 8/18/00 | 21.84 | 22.70 | 9.14 | 15.49 |
| 8/19/00 | 20.52 | 22.25 | 9.14 | 14.83 |
| 8/20/00 | 20.52 | 21.94 | 8.37 | 14.45 |
| 8/21/00 | 21.34 | 21.72 | 6.82 | 14.08 |
| 8/22/00 | 22.34 | 21.72 | 7.76 | 15.05 |
| 8/23/00 | 22.84 | 21.75 | 8.99 | 15.92 |
| 8/24/00 | 22.67 | 21.72 | 12.26 | 17.47 |
| 8/25/00 | 21.01 | 21.61 | 8.37 | 14.69 |
| 8/26/00 | 21.18 | 21.70 | 8.53 | 14.86 |
| 8/27/00 | 19.71 | 21.58 | 7.6 | 13.66 |
| 8/28/00 | 19.71 | 21.35 | 6.36 | 13.04 |
| 8/29/00 | 19.22 | 20.91 | 6.82 | 13.02 |
| 8/30/00 | 20.19 | 20.53 | 7.13 | 13.66 |
| 8/31/00 | 17.12 | 19.73 | 6.82 | 11.97 |
| 9/01/00 | 11.79 | 18.42 | 9.14 | 10.47 |
| 9/02/00 | 11.63 | 17.05 | 7.13 | 9.38 |
| 9/03/00 | 10.71 | 15.77 | 4.17 | 7.44 |
| 9/04/00 | 14.11 | 14.97 | 5.26 | 9.69 |
| 9/05/00 | 11.63 | 13.88 | 7.29 | 9.46 |
| 9/06/00 | 13.03 | 12.86 | 4.79 | 8.91 |
| 9/07/00 | 17.44 | 12.91 | 4.32 | 10.88 |
| 9/08/00 | 15.69 | 13.46 | 5.73 | 10.71 |
| 9/09/00 | 14.9 | 13.93 | 4.64 | 9.77 |
| 9/10/00 | 13.34 | 14.31 | 4.64 | 8.99 |
| 9/11/00 | 19.38 | 15.06 | 6.82 | 13.10 |
| 9/12/00 | 18.08 | 15.98 | 7.6 | 12.84 |
| 9/13/00 | 20.19 | 17.00 | 8.37 | 14.28 |
| 9/14/00 | 21.67 | 17.61 | 9.93 | 15.80 |
| 9/15/00 | 21.01 | 18.37 | 10.08 | 15.55 |
| 9/16/00 | 14.58 | 18.32 | 8.99 | 11.79 |
| 9/17/00 | 20.03 | 19.28 | 8.06 | 14.05 |

## Appendix J. Temperature readings from probe located at Lake Creek below Crooked Creek, 2000.

**Site: Lake Creek below Crooked Creek**
**Date Deployed: 6/23/00**
**Date Retrieved: 9/18/00**
**Maximum temperature of 27.46*C occurred on 8/1/00**
**MWAT of 26.22*C occurred on the week 7/27/00 to 8/2/00**

**Max of Temperature (*C)**

| Date Time | Max | MWAT | Min | Avg |
|---|---|---|---|---|
| 6/24/00 | 21.93 | | 8.94 | 15.44 |
| 6/25/00 | 22.94 | | 10.03 | 16.49 |
| 6/26/00 | 22.43 | | 9.72 | 16.08 |
| 6/27/00 | 23.12 | | 9.41 | 16.27 |
| 6/28/00 | 23.63 | | 10.66 | 17.15 |
| 6/29/00 | 24.48 | | 11.43 | 17.96 |
| 6/30/00 | 23.8 | 23.19 | 12.21 | 18.01 |
| 7/01/00 | 20.63 | 23.00 | 12.82 | 16.73 |
| 7/02/00 | 21.93 | 22.86 | 10.19 | 16.06 |
| 7/03/00 | 19.97 | 22.51 | 10.19 | 15.08 |
| 7/04/00 | 17.87 | 21.76 | 8.32 | 13.10 |
| 7/05/00 | 14.69 | 20.48 | 9.57 | 12.13 |
| 7/06/00 | 19.16 | 19.72 | 9.57 | 14.37 |
| 7/07/00 | 20.79 | 19.29 | 9.72 | 15.26 |
| 7/08/00 | 18.19 | 18.94 | 11.12 | 14.66 |
| 7/09/00 | 21.28 | 18.85 | 9.88 | 15.58 |
| 7/10/00 | 22.94 | 19.27 | 9.88 | 16.41 |
| 7/11/00 | 23.12 | 20.02 | 10.81 | 16.97 |
| 7/12/00 | 23.97 | 21.35 | 12.82 | 18.40 |
| 7/13/00 | 24.32 | 22.09 | 12.36 | 18.34 |
| 7/14/00 | 24.32 | 22.59 | 12.51 | 18.42 |
| 7/15/00 | 23.8 | 23.39 | 13.44 | 18.62 |
| 7/16/00 | 18.67 | 23.02 | 11.74 | 15.21 |
| 7/17/00 | 19.32 | 22.50 | 12.67 | 16.00 |
| 7/18/00 | 19.32 | 21.96 | 13.29 | 16.31 |
| 7/19/00 | 23.46 | 21.89 | 11.74 | 17.60 |
| 7/20/00 | 23.29 | 21.74 | 12.67 | 17.98 |
| 7/21/00 | 23.8 | 21.67 | 13.29 | 18.55 |
| 7/22/00 | 24.83 | 21.81 | 13.91 | 19.37 |
| 7/23/00 | 25.34 | 22.77 | 13.44 | 19.39 |
| 7/24/00 | 25 | 23.58 | 12.21 | 18.61 |
| 7/25/00 | 25.34 | 24.44 | 13.29 | 19.32 |
| 7/26/00 | 25.17 | 24.68 | 13.6 | 19.39 |
| 7/27/00 | 25.52 | 25.00 | 13.44 | 19.48 |
| 7/28/00 | 25.87 | 25.30 | 13.76 | 19.82 |
| 7/29/00 | 27.46 | 25.67 | 14.85 | 21.16 |
| 7/30/00 | 24.48 | 25.55 | 16.28 | 20.38 |
| 7/31/00 | 26.57 | 25.77 | 15.96 | 21.27 |
| 8/01/00 | 27.46 | 26.08 | 16.75 | 22.11 |
| 8/02/00 | 26.21 | 26.22 | 14.07 | 20.14 |
| 8/03/00 | 24.32 | 26.05 | 13.91 | 19.12 |
| 8/04/00 | 25.87 | 26.05 | 15.17 | 20.52 |

**Max of Temperature (*C)**

| Date Time | Max | MWAT | Min | Avg |
|---|---|---|---|---|
| 8/05/00 | 25.17 | 25.73 | 13.29 | 19.23 |
| 8/06/00 | 24.14 | 25.68 | 13.13 | 18.64 |
| 8/07/00 | 24.83 | 25.43 | 12.67 | 18.75 |
| 8/08/00 | 24.83 | 25.05 | 12.36 | 18.60 |
| 8/09/00 | 24.66 | 24.83 | 13.13 | 18.90 |
| 8/10/00 | 24.66 | 24.88 | 13.76 | 19.21 |
| 8/11/00 | 24.14 | 24.63 | 12.36 | 18.25 |
| 8/12/00 | 24.14 | 24.49 | 12.05 | 18.10 |
| 8/13/00 | 23.12 | 24.34 | 11.89 | 17.51 |
| 8/14/00 | 23.29 | 24.12 | 10.97 | 17.13 |
| 8/15/00 | 22.6 | 23.80 | 11.12 | 16.86 |
| 8/16/00 | 22.94 | 23.56 | 10.19 | 16.57 |
| 8/17/00 | 23.12 | 23.34 | 10.97 | 17.05 |
| 8/18/00 | 22.43 | 23.09 | 11.43 | 16.93 |
| 8/19/00 | 19.81 | 22.47 | 11.12 | 15.47 |
| 8/20/00 | 21.12 | 22.19 | 10.34 | 15.73 |
| 8/21/00 | 21.44 | 21.92 | 9.1 | 15.27 |
| 8/22/00 | 22.43 | 21.90 | 10.03 | 16.23 |
| 8/23/00 | 22.94 | 21.90 | 11.12 | 17.03 |
| 8/24/00 | 23.29 | 21.92 | 14.07 | 18.68 |
| 8/25/00 | 22.1 | 21.88 | 10.66 | 16.38 |
| 8/26/00 | 21.77 | 22.16 | 10.66 | 16.22 |
| 8/27/00 | 20.47 | 22.06 | 9.88 | 15.18 |
| 8/28/00 | 20.47 | 21.92 | 8.63 | 14.55 |
| 8/29/00 | 19.65 | 21.53 | 9.1 | 14.38 |
| 8/30/00 | 20.79 | 21.22 | 9.1 | 14.95 |
| 8/31/00 | 17.54 | 20.40 | 9.1 | 13.32 |
| 9/01/00 | 13.44 | 19.16 | 10.34 | 11.89 |
| 9/02/00 | 12.67 | 17.86 | 8.63 | 10.65 |
| 9/03/00 | 10.97 | 16.50 | 5.68 | 8.33 |
| 9/04/00 | 14.22 | 15.61 | 6.77 | 10.50 |
| 9/05/00 | 12.05 | 14.53 | 8.79 | 10.42 |
| 9/06/00 | 13.91 | 13.54 | 5.99 | 9.95 |
| 9/07/00 | 17.23 | 13.50 | 5.99 | 11.61 |
| 9/08/00 | 15.64 | 13.81 | 7.71 | 11.68 |
| 9/09/00 | 14.69 | 14.10 | 5.99 | 10.34 |
| 9/10/00 | 13.29 | 14.43 | 6.3 | 9.80 |
| 9/11/00 | 18.83 | 15.09 | 8.32 | 13.58 |
| 9/12/00 | 19.97 | 16.22 | 9.57 | 14.77 |
| 9/13/00 | 19.81 | 17.07 | 9.88 | 14.85 |
| 9/14/00 | 21.28 | 17.64 | 11.74 | 16.51 |
| 9/15/00 | 20.3 | 18.31 | 11.74 | 16.02 |
| 9/16/00 | 15.01 | 18.36 | 11.12 | 13.07 |
| 9/17/00 | 19.81 | 19.29 | 9.57 | 14.69 |

## Appendix K. Temperature readings from probe located at Malheur River below Lake and Big Creeks, 2000.

**Site: Malheur River below Lake and Big**
**Deployed: 6/22/00**
**Retreived: 9/18/00**
**Maximum temperature of 23.25*C occurred on 7/29/00**
**MWAT of 22.25 occurred on the week 7/27/00 to 8/2/00**

**Max of Temperature (*C)**

| Date Time | Max | MWAT | Min | Avg |
|---|---|---|---|---|
| 6/23/2000 | 18.33 | | 8.03 | 13.18 |
| 6/24/2000 | 19.95 | | 7.57 | 13.76 |
| 6/25/2000 | 20.6 | | 8.49 | 14.55 |
| 6/26/2000 | 20.12 | | 8.03 | 14.08 |
| 6/27/2000 | 20.77 | | 7.72 | 14.25 |
| 6/28/2000 | 21.09 | | 8.8 | 14.95 |
| 6/29/2000 | 21.92 | 20.40 | 9.27 | 15.60 |
| 6/30/2000 | 21.26 | 20.82 | 9.88 | 15.57 |
| 7/01/2000 | 18.17 | 20.56 | 10.19 | 14.18 |
| 7/02/2000 | 19.79 | 20.45 | 8.19 | 13.99 |
| 7/03/2000 | 18.01 | 20.14 | 8.49 | 13.25 |
| 7/04/2000 | 15.94 | 19.45 | 6.48 | 11.21 |
| 7/05/2000 | 12.83 | 18.27 | 7.72 | 10.28 |
| 7/06/2000 | 17.05 | 17.58 | 7.88 | 12.47 |
| 7/07/2000 | 18.17 | 17.14 | 7.72 | 12.95 |
| 7/08/2000 | 15.79 | 16.80 | 9.27 | 12.53 |
| 7/09/2000 | 19.14 | 16.70 | 7.72 | 13.43 |
| 7/10/2000 | 20.77 | 17.10 | 7.72 | 14.25 |
| 7/11/2000 | 20.93 | 17.81 | 8.49 | 14.71 |
| 7/12/2000 | 21.42 | 19.04 | 10.04 | 15.73 |
| 7/13/2000 | 21.58 | 19.69 | 9.42 | 15.50 |
| 7/14/2000 | 21.58 | 20.17 | 9.42 | 15.50 |
| 7/15/2000 | 21.09 | 20.93 | 10.04 | 15.57 |
| 7/16/2000 | 15.94 | 20.47 | 8.8 | 12.37 |
| 7/17/2000 | 17.21 | 19.96 | 9.88 | 13.55 |
| 7/18/2000 | 16.42 | 19.32 | 10.19 | 13.31 |
| 7/19/2000 | 20.12 | 19.13 | 9.11 | 14.62 |
| 7/20/2000 | 21.26 | 19.09 | 9.58 | 15.42 |
| 7/21/2000 | 21.42 | 19.07 | 9.73 | 15.58 |
| 7/22/2000 | 21.92 | 19.18 | 10.66 | 16.29 |
| 7/23/2000 | 21.09 | 19.92 | 9.73 | 15.41 |
| 7/24/2000 | 21.26 | 20.50 | 8.49 | 14.88 |
| 7/25/2000 | 21.42 | 21.21 | 9.27 | 15.35 |
| 7/26/2000 | 21.42 | 21.40 | 9.58 | 15.50 |
| 7/27/2000 | 21.92 | 21.49 | 9.58 | 15.75 |
| 7/28/2000 | 22.24 | 21.61 | 9.73 | 15.99 |
| 7/29/2000 | 23.25 | 21.80 | 10.66 | 16.96 |
| 7/30/2000 | 20.44 | 21.71 | 11.59 | 16.02 |
| 7/31/2000 | 22.41 | 21.87 | 11.43 | 16.92 |
| 8/01/2000 | 23.08 | 22.11 | 12.06 | 17.57 |
| 8/02/2000 | 22.41 | 22.25 | 10.04 | 16.23 |
| 8/03/2000 | 20.77 | 22.09 | 9.88 | 15.33 |

**Max of Temperature (*C)**

| Date Time | Max | MWAT | Min | Avg |
|---|---|---|---|---|
| 8/04/2000 | 21.75 | 22.02 | 10.97 | 16.36 |
| 8/05/2000 | 21.58 | 21.78 | 9.73 | 15.66 |
| 8/06/2000 | 20.6 | 21.80 | 9.42 | 15.01 |
| 8/07/2000 | 21.42 | 21.66 | 9.42 | 15.42 |
| 8/08/2000 | 21.42 | 21.42 | 8.96 | 15.19 |
| 8/09/2000 | 21.09 | 21.23 | 9.42 | 15.26 |
| 8/10/2000 | 20.93 | 21.26 | 9.73 | 15.33 |
| 8/11/2000 | 20.6 | 21.09 | 8.8 | 14.70 |
| 8/12/2000 | 20.77 | 20.98 | 8.34 | 14.56 |
| 8/13/2000 | 19.95 | 20.88 | 8.34 | 14.15 |
| 8/14/2000 | 19.95 | 20.67 | 7.57 | 13.76 |
| 8/15/2000 | 19.63 | 20.42 | 7.57 | 13.60 |
| 8/16/2000 | 19.95 | 20.25 | 6.95 | 13.45 |
| 8/17/2000 | 20.28 | 20.16 | 7.57 | 13.93 |
| 8/18/2000 | 19.31 | 19.98 | 8.03 | 13.67 |
| 8/19/2000 | 16.89 | 19.42 | 7.57 | 12.23 |
| 8/20/2000 | 18.17 | 19.17 | 7.11 | 12.64 |
| 8/21/2000 | 18.82 | 19.01 | 6.02 | 12.42 |
| 8/22/2000 | 19.63 | 19.01 | 6.79 | 13.21 |
| 8/23/2000 | 20.12 | 19.03 | 7.88 | 14.00 |
| 8/24/2000 | 19.79 | 18.96 | 10.35 | 15.07 |
| 8/25/2000 | 18.98 | 18.91 | 7.42 | 13.20 |
| 8/26/2000 | 19.14 | 19.24 | 7.57 | 13.36 |
| 8/27/2000 | 17.85 | 19.19 | 6.79 | 12.32 |
| 8/28/2000 | 17.85 | 19.05 | 5.86 | 11.86 |
| 8/29/2000 | 17.37 | 18.73 | 6.33 | 11.85 |
| 8/30/2000 | 18.33 | 18.47 | 6.48 | 12.41 |
| 8/31/2000 | 15.32 | 17.83 | 6.33 | 10.83 |
| 9/01/2000 | 10.82 | 16.67 | 8.34 | 9.58 |
| 9/02/2000 | 11.12 | 15.52 | 6.95 | 9.04 |
| 9/03/2000 | 9.88 | 14.38 | 4.46 | 7.17 |
| 9/04/2000 | 12.52 | 13.62 | 5.24 | 8.88 |
| 9/05/2000 | 10.97 | 12.71 | 6.95 | 8.96 |
| 9/06/2000 | 12.52 | 11.88 | 4.46 | 8.49 |
| 9/07/2000 | 15.94 | 11.97 | 4.62 | 10.28 |
| 9/08/2000 | 14.37 | 12.47 | 5.39 | 9.88 |
| 9/09/2000 | 13.75 | 12.85 | 4.77 | 9.26 |
| 9/10/2000 | 12.52 | 13.23 | 4.62 | 8.57 |
| 9/11/2000 | 17.69 | 13.97 | 6.33 | 12.01 |
| 9/12/2000 | 18.49 | 15.04 | 7.11 | 12.80 |
| 9/13/2000 | 17.85 | 15.80 | 7.42 | 12.64 |
| 9/14/2000 | 19.31 | 16.28 | 8.8 | 14.06 |
| 9/15/2000 | 18.33 | 16.85 | 8.8 | 13.57 |
| 9/16/2000 | 12.98 | 16.74 | 8.03 | 10.51 |
| 9/17/2000 | 18.01 | 17.52 | 7.42 | 12.72 |

## Appendix L. Temperature readings from probe located at Big Creek, one mile below the 16 road, 2000.

**Site: Big Creek 1 mile below 16 road**
**Date Deployed - 6/8/00**
**Date Retrieved - 10/5/00**
**Maximum Temperature of 21.47*C occurred on 7/29/00**
**MWAT of 20.5*C occurred on the week 7/27/00 to 8/2/00**

**Max of Temperature (*C)**

| Date Time | Max | MWAT | Min | Avg |
|---|---|---|---|---|
| 6/09/00 | 10.71 | | 4.67 | 7.69 |
| 6/10/00 | 8.53 | | 4.82 | 6.675 |
| 6/11/00 | 8.69 | | 3.73 | 6.21 |
| 6/12/00 | 10.39 | | 6.38 | 8.385 |
| 6/13/00 | 15.35 | | 4.82 | 10.085 |
| 6/14/00 | 17.09 | | 6.22 | 11.655 |
| 6/15/00 | 16.3 | 12.44 | 8.23 | 12.265 |
| 6/16/00 | 15.98 | 13.19 | 6.07 | 11.025 |
| 6/17/00 | 16.46 | 14.32 | 5.91 | 11.185 |
| 6/18/00 | 15.67 | 15.32 | 6.38 | 11.025 |
| 6/19/00 | 15.83 | 16.10 | 6.38 | 11.105 |
| 6/20/00 | 17.25 | 16.37 | 5.44 | 11.345 |
| 6/21/00 | 19.02 | 16.64 | 6.84 | 12.93 |
| 6/22/00 | 17.89 | 16.87 | 8.07 | 12.98 |
| 6/23/00 | 17.09 | 17.03 | 7.15 | 12.12 |
| 6/24/00 | 18.54 | 17.33 | 6.69 | 12.615 |
| 6/25/00 | 19.02 | 17.81 | 7.61 | 13.315 |
| 6/26/00 | 18.7 | 18.22 | 7 | 12.85 |
| 6/27/00 | 19.34 | 18.51 | 6.84 | 13.09 |
| 6/28/00 | 19.67 | 18.61 | 7.61 | 13.64 |
| 6/29/00 | 20.31 | 18.95 | 8.07 | 14.19 |
| 6/30/00 | 19.67 | 19.32 | 8.53 | 14.1 |
| 7/01/00 | 16.93 | 19.09 | 8.99 | 12.96 |
| 7/02/00 | 18.22 | 18.98 | 7.15 | 12.685 |
| 7/03/00 | 16.77 | 18.70 | 7.61 | 12.19 |
| 7/04/00 | 14.56 | 18.02 | 5.44 | 10 |
| 7/05/00 | 11.63 | 16.87 | 6.84 | 9.235 |
| 7/06/00 | 15.83 | 16.23 | 7.15 | 11.49 |
| 7/07/00 | 17.09 | 15.86 | 6.69 | 11.89 |
| 7/08/00 | 14.41 | 15.50 | 8.23 | 11.32 |
| 7/09/00 | 17.73 | 15.43 | 6.69 | 12.21 |
| 7/10/00 | 19.67 | 15.85 | 6.84 | 13.255 |
| 7/11/00 | 19.51 | 16.55 | 7.31 | 13.41 |
| 7/12/00 | 19.99 | 17.75 | 8.84 | 14.415 |
| 7/13/00 | 20.15 | 18.36 | 8.38 | 14.265 |
| 7/14/00 | 20.15 | 18.80 | 8.23 | 14.19 |
| 7/15/00 | 19.51 | 19.53 | 8.84 | 14.175 |
| 7/16/00 | 14.72 | 19.10 | 7.77 | 11.245 |

**Max of Temperature (*C)**

| Date Time | Max | MWAT | Min | Avg |
|---|---|---|---|---|
| 7/17/00 | 15.98 | 18.57 | 8.84 | 12.41 |
| 7/18/00 | 15.19 | 17.96 | 8.99 | 12.09 |
| 7/19/00 | 18.54 | 17.75 | 8.23 | 13.385 |
| 7/20/00 | 19.99 | 17.73 | 8.53 | 14.26 |
| 7/21/00 | 20.15 | 17.73 | 8.69 | 14.42 |
| 7/22/00 | 20.15 | 17.82 | 9.46 | 14.805 |
| 7/23/00 | 19.67 | 18.52 | 8.69 | 14.18 |
| 7/24/00 | 19.67 | 19.05 | 7.77 | 13.72 |
| 7/25/00 | 19.83 | 19.71 | 8.38 | 14.105 |
| 7/26/00 | 19.83 | 19.90 | 8.53 | 14.18 |
| 7/27/00 | 20.15 | 19.92 | 8.69 | 14.42 |
| 7/28/00 | 20.31 | 19.94 | 8.69 | 14.5 |
| 7/29/00 | 21.47 | 20.13 | 9.61 | 15.54 |
| 7/30/00 | 19.34 | 20.09 | 10.55 | 14.945 |
| 7/31/00 | 20.97 | 20.27 | 10.55 | 15.76 |
| 8/01/00 | 20.8 | 20.41 | 11.17 | 15.985 |
| 8/02/00 | 20.47 | 20.50 | 8.99 | 14.73 |
| 8/03/00 | 19.18 | 20.36 | 8.99 | 14.085 |
| 8/04/00 | 20.15 | 20.34 | 10.24 | 15.195 |
| 8/05/00 | 19.51 | 20.06 | 8.69 | 14.1 |
| 8/06/00 | 19.99 | 20.15 | 8.53 | 14.26 |
| 8/07/00 | 20.31 | 20.06 | 8.69 | 14.5 |
| 8/08/00 | 19.99 | 19.94 | 8.23 | 14.11 |
| 8/09/00 | 19.99 | 19.87 | 8.69 | 14.34 |
| 8/10/00 | 19.67 | 19.94 | 8.99 | 14.33 |
| 8/11/00 | 19.51 | 19.85 | 8.07 | 13.79 |
| 8/12/00 | 19.67 | 19.88 | 7.61 | 13.64 |
| 8/13/00 | 18.7 | 19.69 | 7.61 | 13.155 |
| 8/14/00 | 18.86 | 19.48 | 6.84 | 12.85 |
| 8/15/00 | 18.54 | 19.28 | 7 | 12.77 |
| 8/16/00 | 18.86 | 19.12 | 6.22 | 12.54 |
| 8/17/00 | 19.18 | 19.05 | 6.84 | 13.01 |
| 8/18/00 | 18.06 | 18.84 | 7.31 | 12.685 |
| 8/19/00 | 16.3 | 18.36 | 6.84 | 11.57 |
| 8/20/00 | 16.93 | 18.10 | 6.53 | 11.73 |
| 8/21/00 | 17.73 | 17.94 | 5.29 | 11.51 |
| 8/22/00 | 18.54 | 17.94 | 6.22 | 12.38 |
| 8/23/00 | 19.02 | 17.97 | 7.15 | 13.085 |
| 8/24/00 | 18.7 | 17.90 | 9.46 | 14.08 |
| 8/25/00 | 18.06 | 17.90 | 6.69 | 12.375 |
| 8/26/00 | 18.22 | 18.17 | 7 | 12.61 |
| 8/27/00 | 16.93 | 18.17 | 6.22 | 11.575 |
| 8/28/00 | 17.09 | 18.08 | 5.29 | 11.19 |
| 8/29/00 | 16.62 | 17.81 | 5.76 | 11.19 |
| 8/30/00 | 17.25 | 17.55 | 5.91 | 11.58 |
| 8/31/00 | 14.41 | 16.94 | 5.76 | 10.085 |

**Max of Temperature (*C)**

| Date Time | Max | MWAT | Min | Avg |
|---|---|---|---|---|
| 9/01/00 | 10.08 | 15.80 | 7.61 | 8.845 |
| 9/02/00 | 10.55 | 14.70 | 6.38 | 8.465 |
| 9/03/00 | 9.31 | 13.62 | 3.89 | 6.6 |
| 9/04/00 | 11.63 | 12.84 | 4.82 | 8.225 |
| 9/05/00 | 10.71 | 11.99 | 6.38 | 8.545 |
| 9/06/00 | 11.47 | 11.17 | 4.2 | 7.835 |
| 9/07/00 | 15.03 | 11.25 | 4.2 | 9.615 |
| 9/08/00 | 13.79 | 11.78 | 4.98 | 9.385 |
| 9/09/00 | 13.02 | 12.14 | 4.36 | 8.69 |
| 9/10/00 | 11.93 | 12.51 | 4.04 | 7.985 |
| 9/11/00 | 16.62 | 13.22 | 5.91 | 11.265 |
| 9/12/00 | 16.93 | 14.11 | 6.38 | 11.655 |
| 9/13/00 | 16.77 | 14.87 | 6.84 | 11.805 |
| 9/14/00 | 18.06 | 15.30 | 7.92 | 12.99 |
| 9/15/00 | 17.25 | 15.80 | 7.92 | 12.585 |
| 9/16/00 | 12.24 | 15.69 | 7.31 | 9.775 |
| 9/17/00 | 16.77 | 16.38 | 6.84 | 11.805 |
| 9/18/00 | 16.3 | 16.33 | 6.69 | 11.495 |
| 9/19/00 | 16.62 | 16.29 | 9.61 | 13.115 |
| 9/20/00 | 14.09 | 15.90 | 4.82 | 9.455 |
| 9/21/00 | 13.33 | 15.23 | 6.38 | 9.855 |
| 9/22/00 | 11.17 | 14.36 | 4.36 | 7.765 |
| 9/23/00 | 10.71 | 14.14 | 1.21 | 5.96 |
| 9/24/00 | 10.55 | 13.25 | 1.05 | 5.8 |
| 9/25/00 | 11.93 | 12.63 | 1.52 | 6.725 |
| 9/26/00 | 12.4 | 12.03 | 1.99 | 7.195 |
| 9/27/00 | 12.71 | 11.83 | 2.47 | 7.59 |
| 9/28/00 | 13.33 | 11.83 | 4.36 | 8.845 |
| 9/29/00 | 11.93 | 11.94 | 4.98 | 8.455 |
| 9/30/00 | 12.4 | 12.18 | 4.82 | 8.61 |
| 10/01/00 | 13.48 | 12.60 | 8.23 | 10.855 |
| 10/02/00 | 10.39 | 12.38 | 4.04 | 7.215 |
| 10/03/00 | 10.55 | 12.11 | 1.52 | 6.035 |
| 10/04/00 | 10.24 | 11.76 | 1.21 | 5.725 |

## Appendix M. Temperature readings from probe located at Big Creek below 16 road, 2000.

Site: Big Creek below 16 road
Deployed on 6/21/00
Retreived on 9/18/00
Maximum temperature of 18.64*C on 8/1/00
MWAT of 18*C occurred on the week 7/27/00 to 8/2/00

**Max of Temperature (*C)**

| Date Time | Max | MWAT | Min | Avg |
|---|---|---|---|---|
| 6/22/00 | 15.31 | | 7.56 | 11.44 |
| 6/23/00 | 14.83 | | 6.63 | 10.73 |
| 6/24/00 | 16.09 | | 6.48 | 11.29 |
| 6/25/00 | 16.25 | | 7.25 | 11.75 |
| 6/26/00 | 16.09 | | 6.63 | 11.36 |
| 6/27/00 | 16.57 | | 6.48 | 11.53 |
| 6/28/00 | 17.04 | 16.03 | 7.25 | 12.15 |
| 6/29/00 | 17.36 | 16.32 | 7.71 | 12.54 |
| 6/30/00 | 17.52 | 16.70 | 8.02 | 12.77 |
| 7/1/00 | 14.83 | 16.52 | 8.02 | 11.43 |
| 7/2/00 | 15.46 | 16.41 | 6.48 | 10.97 |
| 7/3/00 | 14.68 | 16.21 | 6.94 | 10.81 |
| 7/4/00 | 12.51 | 15.63 | 5.23 | 8.87 |
| 7/5/00 | 10.66 | 14.72 | 6.32 | 8.49 |
| 7/6/00 | 13.74 | 14.20 | 6.63 | 10.19 |
| 7/7/00 | 14.83 | 13.82 | 6.32 | 10.58 |
| 7/8/00 | 12.51 | 13.48 | 7.56 | 10.04 |
| 7/9/00 | 14.83 | 13.39 | 6.32 | 10.58 |
| 7/10/00 | 16.88 | 13.71 | 6.48 | 11.68 |
| 7/11/00 | 16.57 | 14.29 | 6.79 | 11.68 |
| 7/12/00 | 17.04 | 15.20 | 8.17 | 12.61 |
| 7/13/00 | 17.68 | 15.76 | 7.71 | 12.70 |
| 7/14/00 | 17.52 | 16.15 | 7.56 | 12.54 |
| 7/15/00 | 16.25 | 16.68 | 8.02 | 12.14 |
| 7/16/00 | 12.66 | 16.37 | 7.25 | 9.96 |
| 7/17/00 | 13.12 | 15.83 | 8.33 | 10.73 |
| 7/18/00 | 13.89 | 15.45 | 8.17 | 11.03 |
| 7/19/00 | 17.68 | 15.54 | 7.71 | 12.70 |
| 7/20/00 | 17.52 | 15.52 | 7.87 | 12.70 |
| 7/21/00 | 17.52 | 15.52 | 8.02 | 12.77 |
| 7/22/00 | 17.84 | 15.75 | 8.63 | 13.24 |
| 7/23/00 | 17.36 | 16.42 | 7.71 | 12.54 |
| 7/24/00 | 17.52 | 17.05 | 7.09 | 12.31 |
| 7/25/00 | 17.84 | 17.61 | 7.71 | 12.78 |
| 7/26/00 | 17.68 | 17.61 | 7.87 | 12.78 |
| 7/27/00 | 17.52 | 17.61 | 7.87 | 12.70 |
| 7/28/00 | 18.16 | 17.70 | 8.17 | 13.17 |
| 7/29/00 | 18.48 | 17.79 | 8.79 | 13.64 |
| 7/30/00 | 17.2 | 17.77 | 9.57 | 13.39 |
| 7/31/00 | 17.84 | 17.82 | 9.57 | 13.71 |
| 8/1/00 | 18.64 | 17.93 | 9.72 | 14.18 |
| 8/2/00 | 18.16 | 18.00 | 8.33 | 13.25 |

**Max of Temperature (*C)**

| Date Time | Max | MWAT | Min | Avg |
|---|---|---|---|---|
| 8/3/00 | 16.88 | 17.91 | 8.33 | 12.61 |
| 8/4/00 | 16.88 | 17.73 | 9.1 | 12.99 |
| 8/5/00 | 17.84 | 17.63 | 8.17 | 13.01 |
| 8/6/00 | 17.04 | 17.61 | 8.02 | 12.53 |
| 8/7/00 | 17.84 | 17.61 | 8.02 | 12.93 |
| 8/8/00 | 17.2 | 17.41 | 7.56 | 12.38 |
| 8/9/00 | 17.04 | 17.25 | 8.17 | 12.61 |
| 8/10/00 | 17.04 | 17.27 | 8.17 | 12.61 |
| 8/11/00 | 16.72 | 17.25 | 7.25 | 11.99 |
| 8/12/00 | 16.72 | 17.09 | 7.09 | 11.91 |
| 8/13/00 | 16.41 | 17.00 | 7.09 | 11.75 |
| 8/14/00 | 16.25 | 16.77 | 6.32 | 11.29 |
| 8/15/00 | 15.93 | 16.59 | 6.63 | 11.28 |
| 8/16/00 | 16.09 | 16.45 | 5.86 | 10.98 |
| 8/17/00 | 16.25 | 16.34 | 6.63 | 11.44 |
| 8/18/00 | 15.93 | 16.23 | 6.79 | 11.36 |
| 8/19/00 | 14.52 | 15.91 | 6.32 | 10.42 |
| 8/20/00 | 14.52 | 15.64 | 6.01 | 10.27 |
| 8/21/00 | 14.99 | 15.46 | 5.23 | 10.11 |
| 8/22/00 | 15.93 | 15.46 | 5.86 | 10.90 |
| 8/23/00 | 16.57 | 15.53 | 6.79 | 11.68 |
| 8/24/00 | 16.25 | 15.53 | 8.48 | 12.37 |
| 8/25/00 | 15.78 | 15.51 | 6.63 | 11.21 |
| 8/26/00 | 15.78 | 15.69 | 6.63 | 11.21 |
| 8/27/00 | 14.83 | 15.73 | 5.86 | 10.35 |
| 8/28/00 | 14.68 | 15.69 | 5.08 | 9.88 |
| 8/29/00 | 14.52 | 15.49 | 5.54 | 10.03 |
| 8/30/00 | 14.99 | 15.26 | 5.86 | 10.43 |
| 8/31/00 | 12.66 | 14.75 | 5.54 | 9.10 |
| 9/1/00 | 8.79 | 13.75 | 7.09 | 7.94 |
| 9/2/00 | 8.94 | 12.77 | 5.7 | 7.32 |
| 9/3/00 | 8.17 | 11.82 | 3.82 | 6.00 |
| 9/4/00 | 9.88 | 11.14 | 4.45 | 7.17 |
| 9/5/00 | 9.41 | 10.41 | 6.17 | 7.79 |
| 9/6/00 | 10.5 | 9.76 | 4.29 | 7.40 |
| 9/7/00 | 12.82 | 9.79 | 4.14 | 8.48 |
| 9/8/00 | 12.04 | 10.25 | 5.08 | 8.56 |
| 9/9/00 | 10.81 | 10.52 | 4.29 | 7.55 |
| 9/10/00 | 10.34 | 10.83 | 4.14 | 7.24 |
| 9/11/00 | 13.74 | 11.38 | 5.54 | 9.64 |
| 9/12/00 | 13.12 | 11.91 | 6.17 | 9.65 |
| 9/13/00 | 14.05 | 12.42 | 6.63 | 10.34 |
| 9/14/00 | 15.31 | 12.77 | 7.41 | 11.36 |
| 9/15/00 | 14.68 | 13.15 | 7.41 | 11.05 |
| 9/16/00 | 10.66 | 13.13 | 7.09 | 8.88 |
| 9/17/00 | 14.21 | 13.68 | 6.48 | 10.35 |

## Appendix N. Temperature readings from probe located at Lake Creek below McCoy, 2001.

Site: Lake Creek below McCoy
Deployed on 6/6/01
Retrieved on 9/3/01 (Data memory max)
Maximum temperature of 27.18*C occurred on 8/7/01
MWAT of 25.36*C occurred on the week 6/30/01 to 7/6/01

**Max of Temperature (*C)**

| Date Time | Max | MWAT | Min | Avg |
|---|---|---|---|---|
| 6/07/01 | 17.28 | | 8.22 | 12.75 |
| 6/08/01 | 19.38 | | 8.07 | 13.73 |
| 6/09/01 | 19.54 | | 9.61 | 14.58 |
| 6/10/01 | 15.22 | | 8.07 | 11.65 |
| 6/11/01 | 12.88 | | 7.29 | 10.09 |
| 6/12/01 | 13.96 | | 6.04 | 10.00 |
| 6/13/01 | 19.38 | 16.81 | 4.95 | 12.17 |
| 6/14/01 | 20.03 | 17.20 | 5.88 | 12.96 |
| 6/15/01 | 20.68 | 17.38 | 6.51 | 13.60 |
| 6/16/01 | 21.67 | 17.69 | 6.82 | 14.25 |
| 6/17/01 | 18.08 | 18.10 | 8.37 | 13.23 |
| 6/18/01 | 20.36 | 19.17 | 5.26 | 12.81 |
| 6/19/01 | 21.84 | 20.29 | 6.2 | 14.02 |
| 6/20/01 | 23.35 | 20.86 | 8.07 | 15.71 |
| 6/21/01 | 24.91 | 21.56 | 9.92 | 17.42 |
| 6/22/01 | 24.73 | 22.13 | 10.86 | 17.80 |
| 6/23/01 | 21.84 | 22.16 | 11.63 | 16.74 |
| 6/24/01 | 13.96 | 21.57 | 9.92 | 11.94 |
| 6/25/01 | 16.01 | 20.95 | 6.04 | 11.03 |
| 6/26/01 | 19.71 | 20.64 | 10.71 | 15.21 |
| 6/27/01 | 16.64 | 19.69 | 12.57 | 14.61 |
| 6/28/01 | 19.38 | 18.90 | 8.68 | 14.03 |
| 6/29/01 | 24.04 | 18.80 | 9.14 | 16.59 |
| 6/30/01 | 23.87 | 19.09 | 11.17 | 17.52 |
| 7/01/01 | 25.6 | 20.75 | 11.79 | 18.70 |
| 7/02/01 | 27.01 | 22.32 | 11.63 | 19.32 |
| 7/03/01 | 24.91 | 23.06 | 12.41 | 18.66 |
| 7/04/01 | 26.65 | 24.49 | 14.42 | 20.54 |
| 7/05/01 | 23.01 | 25.01 | 16.64 | 19.83 |
| 7/06/01 | 26.47 | 25.36 | 13.19 | 19.83 |
| 7/07/01 | 23.18 | 25.26 | 11.02 | 17.10 |
| 7/08/01 | 25.43 | 25.24 | 12.57 | 19.00 |
| 7/09/01 | 24.22 | 24.84 | 12.72 | 18.47 |
| 7/10/01 | 21.67 | 24.38 | 13.49 | 17.58 |
| 7/11/01 | 24.56 | 24.08 | 13.65 | 19.11 |
| 7/12/01 | 25.08 | 24.37 | 13.19 | 19.14 |
| 7/13/01 | 23.52 | 23.95 | 11.94 | 17.73 |
| 7/14/01 | 24.56 | 24.15 | 11.63 | 18.10 |
| 7/15/01 | 23.35 | 23.85 | 12.41 | 17.88 |
| 7/16/01 | 21.51 | 23.46 | 12.1 | 16.81 |
| 7/17/01 | 20.19 | 23.25 | 10.08 | 15.14 |
| 7/18/01 | 19.54 | 22.54 | 11.48 | 15.51 |

**Max of Temperature (*C)**

| Date Time | Max | MWAT | Min | Avg |
|---|---|---|---|---|
| 7/19/01 | 19.71 | 21.77 | 8.37 | 14.04 |
| 7/20/01 | 20.03 | 21.27 | 11.17 | 15.60 |
| 7/21/01 | 20.03 | 20.62 | 8.83 | 14.43 |
| 7/22/01 | 23.87 | 20.70 | 8.68 | 16.28 |
| 7/23/01 | 23.01 | 20.91 | 10.08 | 16.55 |
| 7/24/01 | 24.91 | 21.59 | 10.39 | 17.65 |
| 7/25/01 | 24.04 | 22.23 | 10.24 | 17.14 |
| 7/26/01 | 24.56 | 22.92 | 9.61 | 17.09 |
| 7/27/01 | 24.39 | 23.54 | 9.77 | 17.08 |
| 7/28/01 | 23.18 | 23.99 | 10.71 | 16.95 |
| 7/29/01 | 18.41 | 23.21 | 9.46 | 13.94 |
| 7/30/01 | 16.96 | 22.35 | 11.63 | 14.30 |
| 7/31/01 | 21.01 | 21.79 | 9.77 | 15.39 |
| 8/01/01 | 22.67 | 21.60 | 8.37 | 15.52 |
| 8/02/01 | 24.56 | 21.60 | 9.77 | 17.17 |
| 8/03/01 | 23.87 | 21.52 | 9.92 | 16.90 |
| 8/04/01 | 19.06 | 20.93 | 11.32 | 15.19 |
| 8/05/01 | 24.39 | 21.79 | 9.3 | 16.85 |
| 8/06/01 | 25.6 | 23.02 | 11.17 | 18.39 |
| 8/07/01 | 27.18 | 23.90 | 12.41 | 19.80 |
| 8/08/01 | 25.77 | 24.35 | 13.19 | 19.48 |
| 8/09/01 | 21.51 | 23.91 | 14.27 | 17.89 |
| 8/10/01 | 22.34 | 23.69 | 12.57 | 17.46 |
| 8/11/01 | 26.65 | 24.78 | 12.72 | 19.69 |
| 8/12/01 | 22.84 | 24.56 | 12.72 | 17.78 |
| 8/13/01 | 25.08 | 24.48 | 13.19 | 19.14 |
| 8/14/01 | 23.87 | 24.01 | 12.41 | 18.14 |
| 8/15/01 | 25.08 | 23.91 | 13.19 | 19.14 |
| 8/16/01 | 25.6 | 24.49 | 12.57 | 19.09 |
| 8/17/01 | 25.26 | 24.91 | 12.41 | 18.84 |
| 8/18/01 | 24.91 | 24.66 | 11.79 | 18.35 |
| 8/19/01 | 23.18 | 24.71 | 9.46 | 16.32 |
| 8/20/01 | 22.84 | 24.39 | 8.37 | 15.61 |
| 8/21/01 | 22.51 | 24.20 | 9.14 | 15.83 |
| 8/22/01 | 21.84 | 23.73 | 10.39 | 16.12 |
| 8/23/01 | 20.03 | 22.94 | 10.55 | 15.29 |
| 8/24/01 | 22.34 | 22.52 | 8.68 | 15.51 |
| 8/25/01 | 21.84 | 22.08 | 8.37 | 15.11 |
| 8/26/01 | 23.87 | 22.18 | 9.3 | 16.59 |
| 8/27/01 | 24.22 | 22.38 | 11.48 | 17.85 |
| 8/28/01 | 23.35 | 22.50 | 9.92 | 16.64 |
| 8/29/01 | 23.69 | 22.76 | 9.92 | 16.81 |
| 8/30/01 | 21.51 | 22.97 | 9.77 | 15.64 |
| 8/31/01 | 22.67 | 23.02 | 11.79 | 17.23 |
| 9/01/01 | 22.01 | 23.05 | 10.08 | 16.05 |
| 9/02/01 | 20.19 | 22.52 | 9.77 | 14.98 |

## Appendix O. Temperature readings from probe located at Malheur River below Lake and Big Creeks, 2001.

**Site: Malheur River below lake and big creeks**
**Deployed on 6/6/01**
**Retreived on 10/11/01**
**Maximum temperature of 24.2 occurred on 7/4/01**
**MWAT of 22.37*C occurred on the week 7/1/01 to 7/7/01**

**Max of Temperature (*C)**

| Date Time | Max | MWAT | Min | Avg |
|---|---|---|---|---|
| 6/7/01 | 16.79 | | 7.62 | 12.21 |
| 6/8/01 | 17.92 | | 7.46 | 12.69 |
| 6/9/01 | 18.08 | | 8.54 | 13.31 |
| 6/10/01 | 13.96 | | 7.46 | 10.71 |
| 6/11/01 | 11.79 | | 6.84 | 9.32 |
| 6/12/01 | 12.1 | | 5.59 | 8.85 |
| 6/13/01 | 17.92 | 15.51 | 4.34 | 11.13 |
| 6/14/01 | 18.72 | 15.78 | 5.91 | 12.32 |
| 6/15/01 | 18.89 | 15.92 | 6.22 | 12.56 |
| 6/16/01 | 19.54 | 16.13 | 6.53 | 13.04 |
| 6/17/01 | 16.32 | 16.47 | 7.62 | 11.97 |
| 6/18/01 | 18.4 | 17.41 | 4.82 | 11.61 |
| 6/19/01 | 20.02 | 18.54 | 5.91 | 12.97 |
| 6/20/01 | 21.16 | 19.01 | 7.62 | 14.39 |
| 6/21/01 | 22.66 | 19.57 | 9 | 15.83 |
| 6/22/01 | 22.33 | 20.06 | 9.93 | 16.13 |
| 6/23/01 | 19.7 | 20.08 | 10.24 | 14.97 |
| 6/24/01 | 13.18 | 19.64 | 8.69 | 10.94 |
| 6/25/01 | 14.89 | 19.13 | 5.13 | 10.01 |
| 6/26/01 | 17.76 | 18.81 | 9.31 | 13.54 |
| 6/27/01 | 13.96 | 17.78 | 10.87 | 12.42 |
| 6/28/01 | 19.7 | 17.36 | 7.93 | 13.82 |
| 6/29/01 | 21.16 | 17.19 | 8.08 | 14.62 |
| 6/30/01 | 20.34 | 17.28 | 9.46 | 14.90 |
| 7/1/01 | 22.83 | 18.66 | 9.77 | 16.30 |
| 7/2/01 | 23.68 | 19.92 | 10.09 | 16.89 |
| 7/3/01 | 22.16 | 20.55 | 10.71 | 16.44 |
| 7/4/01 | 24.2 | 22.01 | 12.41 | 18.31 |
| 7/5/01 | 20.02 | 22.06 | 13.96 | 16.99 |
| 7/6/01 | 23.34 | 22.37 | 11.48 | 17.41 |
| 7/7/01 | 20.34 | 22.37 | 9.31 | 14.83 |
| 7/8/01 | 21.83 | 22.22 | 10.56 | 16.20 |
| 7/9/01 | 21 | 21.84 | 10.87 | 15.94 |
| 7/10/01 | 18.56 | 21.33 | 11.33 | 14.95 |
| 7/11/01 | 22.83 | 21.13 | 11.48 | 17.16 |
| 7/12/01 | 21.49 | 21.34 | 11.18 | 16.34 |
| 7/13/01 | 19.86 | 20.84 | 9.93 | 14.90 |
| 7/14/01 | 20.51 | 20.87 | 9.62 | 15.07 |
| 7/15/01 | 20.67 | 20.70 | 10.56 | 15.62 |
| 7/16/01 | 18.24 | 20.31 | 10.56 | 14.40 |
| 7/17/01 | 17.43 | 20.15 | 8.69 | 13.06 |
| 7/18/01 | 16.01 | 19.17 | 9.77 | 12.89 |

**Max of Temperature (*C)**

| Date Time | Max | MWAT | Min | Avg |
|---|---|---|---|---|
| 7/19/01 | 17.76 | 18.64 | 7.15 | 12.46 |
| 7/20/01 | 16.79 | 18.20 | 9.77 | 13.28 |
| 7/21/01 | 17.27 | 17.74 | 7.62 | 12.45 |
| 7/22/01 | 19.86 | 17.62 | 7.93 | 13.90 |
| 7/23/01 | 20.67 | 17.97 | 9 | 14.84 |
| 7/24/01 | 21.49 | 18.55 | 9 | 15.25 |
| 7/25/01 | 20.51 | 19.19 | 8.85 | 14.68 |
| 7/26/01 | 20.51 | 19.59 | 8.54 | 14.53 |
| 7/27/01 | 20.34 | 20.09 | 8.69 | 14.52 |
| 7/28/01 | 19.37 | 20.39 | 9 | 14.19 |
| 7/29/01 | 15.69 | 19.80 | 8.08 | 11.89 |
| 7/30/01 | 14.74 | 18.95 | 9.77 | 12.26 |
| 7/31/01 | 17.92 | 18.44 | 8.23 | 13.08 |
| 8/1/01 | 19.21 | 18.25 | 7.46 | 13.34 |
| 8/2/01 | 20.34 | 18.23 | 8.54 | 14.44 |
| 8/3/01 | 19.21 | 18.07 | 9 | 14.11 |
| 8/4/01 | 15.85 | 17.57 | 9.62 | 12.74 |
| 8/5/01 | 20.02 | 18.18 | 8.08 | 14.05 |
| 8/6/01 | 21.33 | 19.13 | 9.31 | 15.32 |
| 8/7/01 | 21.99 | 19.71 | 10.24 | 16.12 |
| 8/8/01 | 21.33 | 20.01 | 10.87 | 16.10 |
| 8/9/01 | 17.76 | 19.64 | 11.79 | 14.78 |
| 8/10/01 | 18.72 | 19.57 | 10.4 | 14.56 |
| 8/11/01 | 20.51 | 20.24 | 10.87 | 15.69 |
| 8/12/01 | 18.72 | 20.05 | 10.56 | 14.64 |
| 8/13/01 | 19.7 | 19.82 | 10.87 | 15.29 |
| 8/14/01 | 18.08 | 19.26 | 10.56 | 14.32 |
| 8/15/01 | 20.83 | 19.19 | 10.87 | 15.85 |
| 8/16/01 | 20.18 | 19.53 | 10.56 | 15.37 |
| 8/17/01 | 20.18 | 19.74 | 10.56 | 15.37 |
| 8/18/01 | 19.37 | 19.58 | 10.24 | 14.81 |
| 8/19/01 | 18.56 | 19.56 | 8.69 | 13.63 |
| 8/20/01 | 17.92 | 19.30 | 7.62 | 12.77 |
| 8/21/01 | 18.4 | 19.35 | 8.54 | 13.47 |
| 8/22/01 | 17.92 | 18.93 | 8.85 | 13.39 |
| 8/23/01 | 16.01 | 18.34 | 9.31 | 12.66 |
| 8/24/01 | 17.76 | 17.99 | 8.08 | 12.92 |
| 8/25/01 | 17.43 | 17.71 | 7.77 | 12.60 |
| 8/26/01 | 18.72 | 17.74 | 8.85 | 13.79 |
| 8/27/01 | 18.72 | 17.85 | 10.24 | 14.48 |
| 8/28/01 | 18.4 | 17.85 | 9.46 | 13.93 |
| 8/29/01 | 18.72 | 17.97 | 9.62 | 14.17 |
| 8/30/01 | 16.79 | 18.08 | 9.46 | 13.13 |
| 8/31/01 | 17.76 | 18.08 | 10.56 | 14.16 |
| 9/1/01 | 17.11 | 18.03 | 9.62 | 13.37 |
| 9/2/01 | 17.76 | 17.89 | 9.46 | 13.61 |
| 9/3/01 | 17.76 | 17.76 | 9.62 | 13.69 |
| 9/4/01 | 17.27 | 17.60 | 9.31 | 13.29 |
| 9/5/01 | 14.11 | 16.94 | 9.93 | 12.02 |
| 9/6/01 | 13.34 | 16.44 | 6.53 | 9.94 |

**Max of Temperature (*C)**

| Date Time | Max | MWAT | Min | Avg |
|---|---|---|---|---|
| 9/7/01 | 13.8 | 15.88 | 6.68 | 10.24 |
| 9/8/01 | 13.8 | 15.41 | 5.28 | 9.54 |
| 9/9/01 | 14.27 | 14.91 | 5.59 | 9.93 |
| 9/10/01 | 13.8 | 14.34 | 6.53 | 10.17 |
| 9/11/01 | 15.37 | 14.07 | 7.15 | 11.26 |
| 9/12/01 | 14.74 | 14.16 | 9.31 | 12.03 |
| 9/13/01 | 16.96 | 14.68 | 10.24 | 13.60 |
| 9/14/01 | 14.74 | 14.81 | 10.24 | 12.49 |
| 9/15/01 | 13.03 | 14.70 | 8.39 | 10.71 |
| 9/16/01 | 11.48 | 14.30 | 7.31 | 9.40 |
| 9/17/01 | 15.37 | 14.53 | 7.77 | 11.57 |
| 9/18/01 | 14.58 | 14.41 | 7.62 | 11.10 |
| 9/19/01 | 13.18 | 14.19 | 6.84 | 10.01 |
| 9/20/01 | 13.65 | 13.72 | 5.75 | 9.70 |
| 9/21/01 | 12.88 | 13.45 | 6.22 | 9.55 |
| 9/22/01 | 13.96 | 13.59 | 6.22 | 10.09 |
| 9/23/01 | 13.65 | 13.90 | 6.68 | 10.17 |
| 9/24/01 | 13.49 | 13.63 | 7.15 | 10.32 |
| 9/25/01 | 10.24 | 13.01 | 7.31 | 8.78 |
| 9/26/01 | 12.26 | 12.88 | 7.15 | 9.71 |
| 9/27/01 | 13.34 | 12.83 | 7.62 | 10.48 |
| 9/28/01 | 11.79 | 12.68 | 8.23 | 10.01 |
| 9/29/01 | 12.26 | 12.43 | 4.97 | 8.62 |
| 9/30/01 | 12.41 | 12.26 | 5.13 | 8.77 |
| 10/1/01 | 12.72 | 12.15 | 5.59 | 9.16 |
| 10/2/01 | 12.41 | 12.46 | 5.91 | 9.16 |
| 10/3/01 | 11.64 | 12.37 | 5.28 | 8.46 |
| 10/4/01 | 11.33 | 12.08 | 5.28 | 8.31 |
| 10/5/01 | 10.24 | 11.86 | 4.03 | 7.14 |
| 10/6/01 | 10.4 | 11.59 | 4.19 | 7.30 |
| 10/7/01 | 7.62 | 10.91 | 4.03 | 5.83 |
| 10/8/01 | 8.23 | 10.27 | 3.25 | 5.74 |
| 10/9/01 | 7.62 | 9.58 | 3.41 | 5.52 |
| 10/10/01 | 5.59 | 8.72 | 1.51 | 3.55 |

## Appendix P. Temperature readings from probe located at Big Creek, one mile below the 16 road, 2001.

Site: Big Creek 1 mile below 16 rd
Deployed on 6/6/01
Retrieved on 10/11/01
Maximum temperature of 22.63*C occurred on 7/4/01
MWAT of 21.13*C occurred on the week 7/1/01 to 7/7/01

**Max of Temperature (*C)**

| Date Time | Max | MWAT | Min | AVG |
|---|---|---|---|---|
| 6/07/01 | 15.35 | | 6.84 | 11.10 |
| 6/08/01 | 16.46 | | 6.53 | 11.50 |
| 6/09/01 | 16.62 | | 7.61 | 12.12 |
| 6/10/01 | 12.87 | | 6.38 | 9.63 |
| 6/11/01 | 10.86 | | 6.07 | 8.47 |
| 6/12/01 | 11.93 | | 5.13 | 8.53 |
| 6/13/01 | 17.09 | 14.45 | 3.89 | 10.49 |
| 6/14/01 | 17.73 | 14.79 | 4.82 | 11.28 |
| 6/15/01 | 17.73 | 14.98 | 5.29 | 11.51 |
| 6/16/01 | 18.54 | 15.25 | 5.6 | 12.07 |
| 6/17/01 | 15.35 | 15.60 | 6.69 | 11.02 |
| 6/18/01 | 17.41 | 16.54 | 4.2 | 10.81 |
| 6/19/01 | 18.86 | 17.53 | 5.13 | 12.00 |
| 6/20/01 | 19.83 | 17.92 | 6.69 | 13.26 |
| 6/21/01 | 21.47 | 18.46 | 8.07 | 14.77 |
| 6/22/01 | 21.13 | 18.94 | 8.84 | 14.99 |
| 6/23/01 | 18.38 | 18.92 | 9.15 | 13.77 |
| 6/24/01 | 11.47 | 18.36 | 7.46 | 9.47 |
| 6/25/01 | 13.79 | 17.85 | 4.51 | 9.15 |
| 6/26/01 | 16.77 | 17.55 | 8.38 | 12.58 |
| 6/27/01 | 12.71 | 16.53 | 9.15 | 10.93 |
| 6/28/01 | 18.38 | 16.09 | 6.84 | 12.61 |
| 6/29/01 | 19.99 | 15.93 | 7.15 | 13.57 |
| 6/30/01 | 19.18 | 16.04 | 8.38 | 13.78 |
| 7/01/01 | 21.47 | 17.47 | 8.84 | 15.16 |
| 7/02/01 | 22.47 | 18.71 | 8.99 | 15.73 |
| 7/03/01 | 20.97 | 19.31 | 9.77 | 15.37 |
| 7/04/01 | 22.63 | 20.73 | 11.17 | 16.90 |
| 7/05/01 | 18.86 | 20.80 | 12.71 | 15.79 |
| 7/06/01 | 21.97 | 21.08 | 10.24 | 16.11 |
| 7/07/01 | 19.51 | 21.13 | 8.38 | 13.95 |
| 7/08/01 | 21.3 | 21.10 | 9.61 | 15.46 |
| 7/09/01 | 20.15 | 20.77 | 9.77 | 14.96 |
| 7/10/01 | 17.73 | 20.31 | 10.24 | 13.99 |
| 7/11/01 | 21.63 | 20.16 | 10.39 | 16.01 |
| 7/12/01 | 20.8 | 20.44 | 10.08 | 15.44 |
| 7/13/01 | 19.02 | 20.02 | 8.99 | 14.01 |
| 7/14/01 | 19.83 | 20.07 | 8.69 | 14.26 |
| 7/15/01 | 19.67 | 19.83 | 9.61 | 14.64 |
| 7/16/01 | 17.57 | 19.46 | 9.46 | 13.52 |
| 7/17/01 | 16.62 | 19.31 | 7.77 | 12.20 |
| 7/18/01 | 15.67 | 18.45 | 8.84 | 12.26 |

**Max of Temperature (*C)**

| Date Time | Max | MWAT | Min | AVG |
|---|---|---|---|---|
| 7/19/01 | 17.09 | 17.92 | 6.53 | 11.81 |
| 7/20/01 | 16.46 | 17.56 | 8.84 | 12.65 |
| 7/21/01 | 16.77 | 17.12 | 6.69 | 11.73 |
| 7/22/01 | 18.86 | 17.01 | 7 | 12.93 |
| 7/23/01 | 20.64 | 17.44 | 7.92 | 14.28 |
| 7/24/01 | 20.97 | 18.07 | 8.23 | 14.60 |
| 7/25/01 | 20.15 | 18.71 | 7.77 | 13.96 |
| 7/26/01 | 20.31 | 19.17 | 7.46 | 13.89 |
| 7/27/01 | 20.31 | 19.72 | 7.61 | 13.96 |
| 7/28/01 | 19.02 | 20.04 | 8.07 | 13.55 |
| 7/29/01 | 15.03 | 19.49 | 7.31 | 11.17 |
| 7/30/01 | 14.09 | 18.55 | 8.99 | 11.54 |
| 7/31/01 | 17.41 | 18.05 | 7.46 | 12.44 |
| 8/01/01 | 18.86 | 17.86 | 6.53 | 12.70 |
| 8/02/01 | 20.31 | 17.86 | 7.77 | 14.04 |
| 8/03/01 | 19.18 | 17.70 | 7.77 | 13.48 |
| 8/04/01 | 15.67 | 17.22 | 8.38 | 12.03 |
| 8/05/01 | 19.99 | 17.93 | 7 | 13.50 |
| 8/06/01 | 20.97 | 18.91 | 8.38 | 14.68 |
| 8/07/01 | 21.8 | 19.54 | 9.31 | 15.56 |
| 8/08/01 | 20.97 | 19.84 | 9.93 | 15.45 |
| 8/09/01 | 17.41 | 19.43 | 10.71 | 14.06 |
| 8/10/01 | 18.22 | 19.29 | 9.15 | 13.69 |
| 8/11/01 | 20.47 | 19.98 | 9.61 | 15.04 |
| 8/12/01 | 18.54 | 19.77 | 9.31 | 13.93 |
| 8/13/01 | 19.67 | 19.58 | 9.61 | 14.64 |
| 8/14/01 | 17.89 | 19.02 | 9.31 | 13.60 |
| 8/15/01 | 20.64 | 18.98 | 9.77 | 15.21 |
| 8/16/01 | 20.31 | 19.39 | 9.31 | 14.81 |
| 8/17/01 | 20.64 | 19.74 | 9.15 | 14.90 |
| 8/18/01 | 19.83 | 19.65 | 8.69 | 14.26 |
| 8/19/01 | 18.7 | 19.67 | 7.31 | 13.01 |
| 8/20/01 | 18.7 | 19.53 | 6.38 | 12.54 |
| 8/21/01 | 18.54 | 19.62 | 7 | 12.77 |
| 8/22/01 | 18.54 | 19.32 | 7.77 | 13.16 |
| 8/23/01 | 16.46 | 18.77 | 8.23 | 12.35 |
| 8/24/01 | 18.22 | 18.43 | 6.84 | 12.53 |
| 8/25/01 | 18.06 | 18.17 | 6.38 | 12.22 |
| 8/26/01 | 19.83 | 18.34 | 7.15 | 13.49 |
| 8/27/01 | 19.67 | 18.47 | 8.69 | 14.18 |
| 8/28/01 | 19.02 | 18.54 | 7.61 | 13.32 |
| 8/29/01 | 19.51 | 18.68 | 7.77 | 13.64 |
| 8/30/01 | 17.73 | 18.86 | 7.61 | 12.67 |
| 8/31/01 | 18.7 | 18.93 | 8.99 | 13.85 |
| 9/01/01 | 18.06 | 18.93 | 7.77 | 12.92 |
| 9/02/01 | 18.7 | 18.77 | 7.61 | 13.16 |
| 9/03/01 | 18.7 | 18.63 | 7.77 | 13.24 |
| 9/04/01 | 18.38 | 18.54 | 7.31 | 12.85 |
| 9/05/01 | 14.72 | 17.86 | 6.84 | 10.78 |
| 9/06/01 | 13.94 | 17.31 | 4.67 | 9.31 |

**Max of Temperature (*C)**

| Date Time | Max | MWAT | Min | AVG |
|---|---|---|---|---|
| 9/07/01 | 14.72 | 16.75 | 4.82 | 9.77 |
| 9/08/01 | 14.88 | 16.29 | 3.26 | 9.07 |
| 9/09/01 | 15.51 | 15.84 | 3.73 | 9.62 |
| 9/10/01 | 14.72 | 15.27 | 4.82 | 9.77 |
| 9/11/01 | 16.77 | 15.04 | 5.6 | 11.19 |
| 9/12/01 | 15.83 | 15.20 | 7.92 | 11.88 |
| 9/13/01 | 18.54 | 15.85 | 9.15 | 13.85 |
| 9/14/01 | 15.03 | 15.90 | 8.84 | 11.94 |
| 9/15/01 | 14.25 | 15.81 | 6.69 | 10.47 |
| 9/16/01 | 12.87 | 15.43 | 5.76 | 9.32 |
| 9/17/01 | 16.77 | 15.72 | 6.22 | 11.50 |
| 9/18/01 | 15.67 | 15.57 | 5.91 | 10.79 |
| 9/19/01 | 14.09 | 15.32 | 4.98 | 9.54 |
| 9/20/01 | 14.72 | 14.77 | 4.04 | 9.38 |
| 9/21/01 | 13.79 | 14.59 | 4.51 | 9.15 |
| 9/22/01 | 15.03 | 14.71 | 4.67 | 9.85 |
| 9/23/01 | 14.72 | 14.97 | 5.13 | 9.93 |
| 9/24/01 | 14.56 | 14.65 | 5.6 | 10.08 |
| 9/25/01 | 10.71 | 13.95 | 6.07 | 8.39 |
| 9/26/01 | 13.63 | 13.88 | 6.07 | 9.85 |
| 9/27/01 | 14.25 | 13.81 | 6.53 | 10.39 |
| 9/28/01 | 12.09 | 13.57 | 6.84 | 9.47 |
| 9/29/01 | 13.33 | 13.33 | 3.26 | 8.30 |
| 9/30/01 | 13.79 | 13.19 | 3.42 | 8.61 |
| 10/01/01 | 14.25 | 13.15 | 4.04 | 9.15 |
| 10/02/01 | 13.79 | 13.59 | 4.36 | 9.08 |
| 10/03/01 | 13.02 | 13.50 | 3.73 | 8.38 |
| 10/04/01 | 12.71 | 13.28 | 3.73 | 8.22 |
| 10/05/01 | 11.47 | 13.19 | 2.31 | 6.89 |
| 10/06/01 | 11.78 | 12.97 | 2.63 | 7.21 |
| 10/07/01 | 7.92 | 12.13 | 2.47 | 5.20 |
| 10/08/01 | 9.31 | 11.43 | 1.99 | 5.65 |
| 10/09/01 | 8.84 | 10.72 | 2.31 | 5.58 |
| 10/10/01 | 6.22 | 9.75 | 0.09 | 3.16 |

## Appendix Q. Temperature readings from probe located at Big Creek at the 16 road, 2001.

**Site: Big Creek @ 16 rd**
**Deployed: 6/25/01**
**Retrieved: 10/10/01**
**Maximum temperature 18.63 occurred on 7/4/01**
**MWAT of 17.12*C occurred on 7/6/01**

**Max of Temperature (*C)**

| Date Time | Max | Min | Avg | MWAT |
|---|---|---|---|---|
| 6/26/01 | 13.71 | 6.59 | 10.15 | |
| 6/27/01 | 9.68 | 7.52 | 8.60 | |
| 6/28/01 | 12.63 | 5.18 | 8.91 | |
| 6/29/01 | 16.22 | 5.65 | 10.94 | |
| 6/30/01 | 15.75 | 6.74 | 11.25 | |
| 7/01/01 | 17.66 | 6.74 | 12.20 | |
| 7/02/01 | 18.31 | 6.9 | 12.61 | 14.85 |
| 7/03/01 | 17.18 | 7.52 | 12.35 | 15.35 |
| 7/04/01 | 18.63 | 8.75 | 13.69 | 16.63 |
| 7/05/01 | 14.33 | 9.84 | 12.09 | 16.87 |
| 7/06/01 | 17.98 | 7.83 | 12.91 | 17.12 |
| 7/07/01 | 15.43 | 6.43 | 10.93 | 17.07 |
| 7/08/01 | 17.82 | 7.83 | 12.83 | 17.10 |
| 7/09/01 | 16.22 | 7.67 | 11.95 | 16.80 |
| 7/10/01 | 14.18 | 7.83 | 11.01 | 16.37 |
| 7/11/01 | 17.18 | 8.13 | 12.66 | 16.16 |
| 7/12/01 | 15.75 | 7.67 | 11.71 | 16.37 |
| 7/13/01 | 15.27 | 7.06 | 11.17 | 15.98 |
| 7/14/01 | 16.38 | 6.74 | 11.56 | 16.11 |
| 7/15/01 | 15.91 | 7.37 | 11.64 | 15.84 |
| 7/16/01 | 14.64 | 7.52 | 11.08 | 15.62 |
| 7/17/01 | 13.25 | 5.81 | 9.53 | 15.48 |
| 7/18/01 | 12.32 | 6.9 | 9.61 | 14.79 |
| 7/19/01 | 13.56 | 4.87 | 9.22 | 14.48 |
| 7/20/01 | 13.25 | 6.9 | 10.08 | 14.19 |
| 7/21/01 | 13.09 | 5.03 | 9.06 | 13.72 |
| 7/22/01 | 15.12 | 5.49 | 10.31 | 13.60 |
| 7/23/01 | 16.38 | 6.28 | 11.33 | 13.85 |
| 7/24/01 | 17.02 | 6.28 | 11.65 | 14.39 |
| 7/25/01 | 16.7 | 5.97 | 11.34 | 15.02 |
| 7/26/01 | 16.54 | 5.65 | 11.10 | 15.44 |
| 7/27/01 | 16.86 | 5.81 | 11.34 | 15.96 |
| 7/28/01 | 15.12 | 6.28 | 10.70 | 16.25 |
| 7/29/01 | 11.38 | 5.34 | 8.36 | 15.71 |
| 7/30/01 | 10.92 | 7.06 | 8.99 | 14.93 |
| 7/31/01 | 14.18 | 5.81 | 10.00 | 14.53 |
| 8/01/01 | 15.43 | 5.03 | 10.23 | 14.35 |
| 8/02/01 | 16.7 | 5.97 | 11.34 | 14.37 |
| 8/03/01 | 15.59 | 6.12 | 10.86 | 14.19 |
| 8/04/01 | 12.16 | 6.59 | 9.38 | 13.77 |
| 8/05/01 | 16.22 | 5.65 | 10.94 | 14.46 |
| 8/06/01 | 17.5 | 6.59 | 12.05 | 15.40 |

**Max of Temperature (*C)**

| Date Time | Max | Min | Avg | MWAT |
|---|---|---|---|---|
| 8/07/01 | 17.66 | 7.37 | 12.52 | 15.89 |
| 8/08/01 | 17.5 | 7.83 | 12.67 | 16.19 |
| 8/09/01 | 13.25 | 8.29 | 10.77 | 15.70 |
| 8/10/01 | 14.64 | 7.37 | 11.01 | 15.56 |
| 8/11/01 | 16.38 | 7.67 | 12.03 | 16.16 |
| 8/12/01 | 14.96 | 7.52 | 11.24 | 15.98 |
| 8/13/01 | 16.22 | 7.83 | 12.03 | 15.80 |
| 8/14/01 | 14.49 | 7.52 | 11.01 | 15.35 |
| 8/15/01 | 15.91 | 7.98 | 11.95 | 15.12 |
| 8/16/01 | 16.38 | 7.52 | 11.95 | 15.57 |
| 8/17/01 | 16.54 | 7.52 | 12.03 | 15.84 |
| 8/18/01 | 16.22 | 6.9 | 11.56 | 15.82 |
| 8/19/01 | 14.8 | 5.49 | 10.15 | 15.79 |
| 8/20/01 | 15.27 | 5.03 | 10.15 | 15.66 |
| 8/21/01 | 14.8 | 5.49 | 10.15 | 15.70 |
| 8/22/01 | 14.64 | 6.12 | 10.38 | 15.52 |
| 8/23/01 | 12.78 | 6.43 | 9.61 | 15.01 |
| 8/24/01 | 14.18 | 5.18 | 9.68 | 14.67 |
| 8/25/01 | 14.02 | 5.03 | 9.53 | 14.36 |
| 8/26/01 | 15.91 | 5.81 | 10.86 | 14.51 |
| 8/27/01 | 15.91 | 6.74 | 11.33 | 14.61 |
| 8/28/01 | 15.12 | 5.97 | 10.55 | 14.65 |
| 8/29/01 | 15.43 | 6.28 | 10.86 | 14.76 |
| 8/30/01 | 14.33 | 6.12 | 10.23 | 14.99 |
| 8/31/01 | 14.96 | 7.21 | 11.09 | 15.10 |
| 9/01/01 | 14.64 | 6.28 | 10.46 | 15.19 |
| 9/02/01 | 14.96 | 5.97 | 10.47 | 15.05 |
| 9/03/01 | 15.12 | 6.12 | 10.62 | 14.94 |
| 9/04/01 | 14.8 | 5.81 | 10.31 | 14.89 |
| 9/05/01 | 11.85 | 5.97 | 8.91 | 14.38 |
| 9/06/01 | 11.38 | 3.47 | 7.43 | 13.96 |
| 9/07/01 | 11.69 | 3.62 | 7.66 | 13.49 |
| 9/08/01 | 11.54 | 2.36 | 6.95 | 13.05 |
| 9/09/01 | 12.16 | 2.99 | 7.58 | 12.65 |
| 9/10/01 | 12.01 | 3.93 | 7.97 | 12.20 |
| 9/11/01 | 13.56 | 4.56 | 9.06 | 12.03 |
| 9/12/01 | 12.47 | 6.43 | 9.45 | 12.12 |
| 9/13/01 | 12.01 | 7.37 | 9.69 | 12.21 |
| 9/14/01 | 11.08 | 6.9 | 8.99 | 12.12 |
| 9/15/01 | 11.38 | 5.49 | 8.44 | 12.10 |
| 9/16/01 | 9.68 | 4.56 | 7.12 | 11.74 |
| 9/17/01 | 12.63 | 5.03 | 8.83 | 11.83 |
| 9/18/01 | 12.16 | 4.72 | 8.44 | 11.63 |
| 9/19/01 | 11.23 | 3.93 | 7.58 | 11.45 |
| 9/20/01 | 11.54 | 3.15 | 7.35 | 11.39 |
| 9/21/01 | 10.77 | 3.62 | 7.20 | 11.34 |
| 9/22/01 | 11.85 | 3.93 | 7.89 | 11.41 |
| 9/23/01 | 11.54 | 4.4 | 7.97 | 11.67 |
| 9/24/01 | 11.38 | 4.72 | 8.05 | 11.50 |
| 9/25/01 | 8.13 | 5.18 | 6.66 | 10.92 |

**Max of Temperature (*C)**

| Date Time | Max | Min | Avg | MWAT |
|---|---|---|---|---|
| 9/26/01 | 9.99 | 4.56 | 7.28 | 10.74 |
| 9/27/01 | 11.08 | 5.18 | 8.13 | 10.68 |
| 9/28/01 | 9.37 | 5.65 | 7.51 | 10.48 |
| 9/29/01 | 9.99 | 2.68 | 6.34 | 10.21 |
| 9/30/01 | 10.46 | 2.84 | 6.65 | 10.06 |
| 10/01/01 | 11.08 | 3.62 | 7.35 | 10.01 |
| 10/02/01 | 10.62 | 3.78 | 7.20 | 10.37 |
| 10/03/01 | 9.99 | 2.99 | 6.49 | 10.37 |
| 10/04/01 | 9.53 | 3.15 | 6.34 | 10.15 |
| 10/05/01 | 8.44 | 1.88 | 5.16 | 10.02 |
| 10/06/01 | 9.06 | 2.2 | 5.63 | 9.88 |
| 10/07/01 | 6.28 | 1.88 | 4.08 | 9.29 |
| 10/08/01 | 6.74 | 1.72 | 4.23 | 8.67 |
| 10/09/01 | 5.97 | 1.72 | 3.85 | 8.00 |
| 10/10/01 | 4.56 | 0.12 | 2.34 | 7.23 |